UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 44

COLES COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, AND L. H. SMITH

URBANA, ILLINOIS, AUGUST, 1929

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

[1] Engaged in Soils Extension as well as in Soil Experiment Fields.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Coles county was conducted, and Mr. W. P. Hiltabrand, who as leader of the field party, was in direct charge of the mapping.

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APPENDIX

SUPPLEMENT

COLES COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER and L. H. SMITH[1]

LOCATION AND CLIMATE OF COLES COUNTY

Coles county is located in the east-central part of Illinois. It is a medium-sized county, covering 508.84 square miles, over half of which is dark-colored upland soil.

The climate of Coles county is typical of central Illinois. The rainfall is abundant and usually well distributed and, while there is a wide range between the extremes of summer and winter temperature, there are but a few days during the winter when subzero weather prevails. Summer temperatures are, as a rule, not oppressive. The following weather data is taken from the records of the Cooperative Weather Bureau Station at Charleston for the thirteen-year period 1914 to 1927, inclusive.

The greatest range in temperature for any one year during this period was 128 degrees in 1918. The highest temperature recorded was 107°; the lowest, 24° below zero. The average date of the last killing frost in the spring is April 26; the first in the fall, October 16. The average length of the growing season is 173 days.

The average annual rainfall during this thirteen-year period was 38.9 inches, distributed as follows: January, 2.33 inches; February, 1.76; March 3.63; April, 3.53; May, 4.11; June, 3.83; July, 3.21; August, 4.35; September, 4.24; October, 3.35; November, 2.30; December, 3.04.

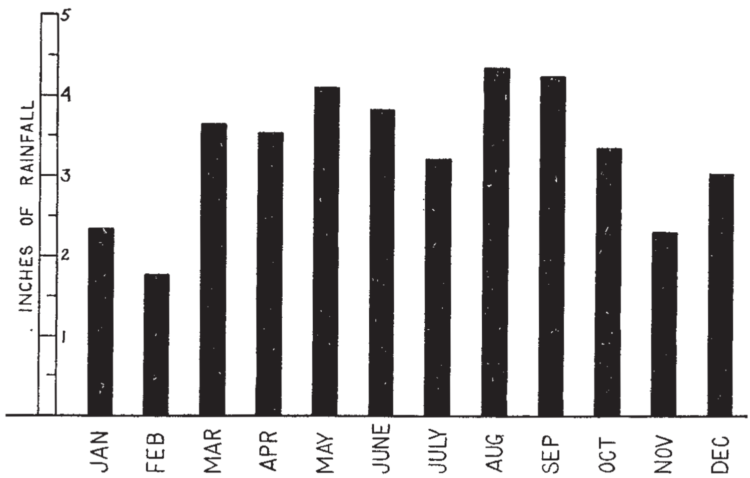

FIG. 1.—THE AVERAGE MONTHLY DISTRIBUTION OF RAINFALL IN COLES COUNTY
It will be noted that the more abundant rainfall occurs mainly during the growing season. This, of course, is favorable for crop production.

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[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

AGRICULTURAL PRODUCTION

About 90 percent of the area of Coles county is good agricultural land and suitable for the production of the crops common to the region. Diversified farming is the rule with a relatively large number of beef cattle and hogs produced. The percentage of farms operated by tenants has decreased from 45.7 in 1910 to 41.8 in 1925. The following figures show the acreage and production of the principal crops for Coles county for the year 1924.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	106,010	3,755,975 bu.	37.1 bu.
Wheat	19,080	400,067 bu.	21.0 bu.
Oats	27,698	1,051,514 bu.	38.0 bu.
Timothy	9,438	....	....
Timothy and clover mixed	8,735	....	....
Clover	9,948	....	....
Alfalfa	1,616	....	....
Total hay	35,021	42,766 tons	1.22 tons
Broom corn	19,250	9,240,000 lbs.	480.0 lbs.

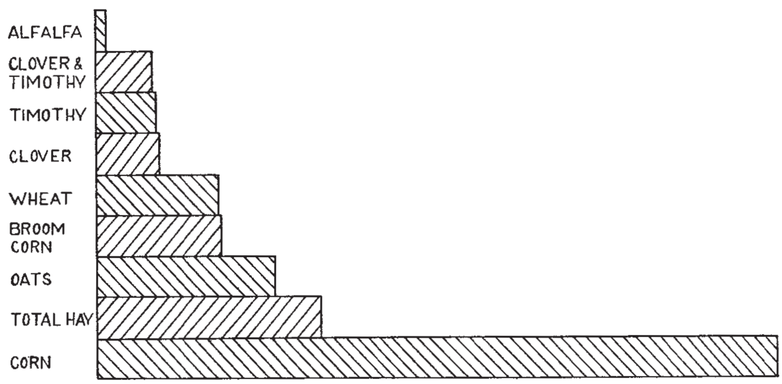

FIG. 2.—RELATIVE ACREAGE OF FIELD CROPS IN COLES COUNTY

The diagram brings out the preponderance of land devoted to the grain crops and broom corn. Legume crops might well occupy a larger proportion of the cultivated acreage. (Data from the 1925 Census.)

These census figures are for a single year only. The following averages for the past ten-year period will probably more nearly represent the true conditions. According to these figures the average yield of corn is 33.6 bushels an acre; wheat, 17.1 bushels; oats, 26.4 bushels; and tame hay, 1.3 tons an acre.

A crop of unusual interest is broom corn, Coles county being in the heart of one of the world's famous broom-corn districts. In production of broom corn this county is far above any other in the state. The acreage given in the above table happens to be unusually high. According to records at hand, it has varied in different years from about 7,000 to over 19,000 acres annually.

Two important crops of rather recent introduction are not mentioned in the above list, namely, soybeans and sweet clover. The increasing interest in soybeans in this section of the country is shown by the fact that last year 5,000 acres in Coles county was devoted to soybeans alone, and on 5,000 other acres soybeans was grown as a companion crop with corn. The great value of sweet clover as a soil-building and pasture crop is becoming more and more recognized.

In 1919, there were only 500 acres of sweet clover in the county; in 1928 the acreage was 15,000.

The following figures show the character of the livestock interests in the county as taken from the census report of 1925.

Animals and Animal Products	*Number*	*Value*
Horses	10,378	$609,912
Mules	2,045	150,270
Cattle (total)	16,861	642,178
Dairy cows	4,981	......
Dairy products	.....	279,899
Sheep	5,856	57,634
Swine	58,325	733,942
Chickens and eggs	.....	518,599
Wool	.....	12,769

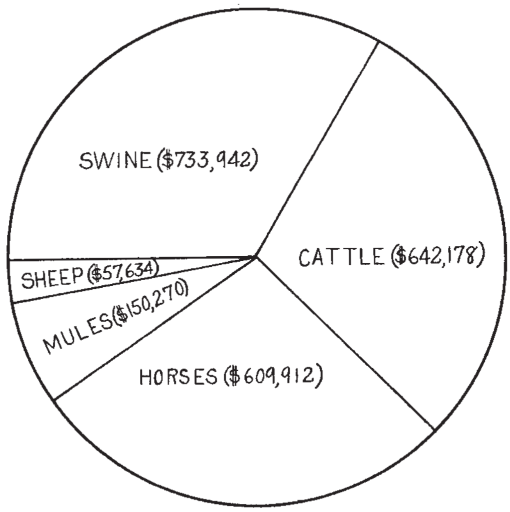

FIG. 3.—RELATIVE VALUE OF THE MORE IMPORTANT CLASSES OF FARM ANIMALS IN COLES COUNTY

Horses, cattle, and swine are the main classes of livestock and are of about equal value in Coles county.

SOIL FORMATION

GEOLOGICAL ASPECTS

One of the most important periods in the geological history of Coles county, from the standpoint of the character of the soils, was the Glacial period. The soils of the county were formed from material laid down during glacial times. Very little wind-blown material occurs in the county other than some formed by the local reworking of fine-textured material.

At least two glacial advances, the Illinoian and early Wisconsin, covered the area that now constitutes Coles county. The glacial debris, known as till or drift, deposited by the Illinoian ice sheet, was buried by the debris deposited by the more recent early Wisconsin ice sheet. Altho the Illinoian drift does not enter into the composition of the soils of Coles county except in the southeast and southwest corners of the county, yet the Illinoian glaciation probably had an important relation to the soils of this county in that it acted as a leveling force, rubbing down the preglacial hills and filling the preglacial valleys.

The terminal moraine of the early Wisconsin glaciation, varying from about 5 to 9 miles in width, extends across the southern part of Coles county. The northern boundary of this moraine is not distinct, while the southern boundary thruout most of its length is marked by an abrupt drop-off. An outwash plain, forming a belt some four or five miles in width, borders the moraine on the south. The outwash plain material lies on an older glaciation. The soils on the outwash plain resemble those to the north more than those to the south, owing to the fact that the material from which they were formed came from the later glaciation.

A considerable portion of Coles county north of the terminal moraine remained for a long period of time under swampy conditions following the retreat of the Wisconsin ice sheet. This condition gave rise to a large proportion of heavy soil with drab-colored subsoil extending for a considerable distance to the north and west of Coles county.

PHYSIOGRAPHY AND DRAINAGE

The portions of Coles county which are occupied by dark-colored soils are for the most part flat to gently undulating. The light-colored area on either side of Kaskaskia river is gently rolling with some small flat areas occurring,

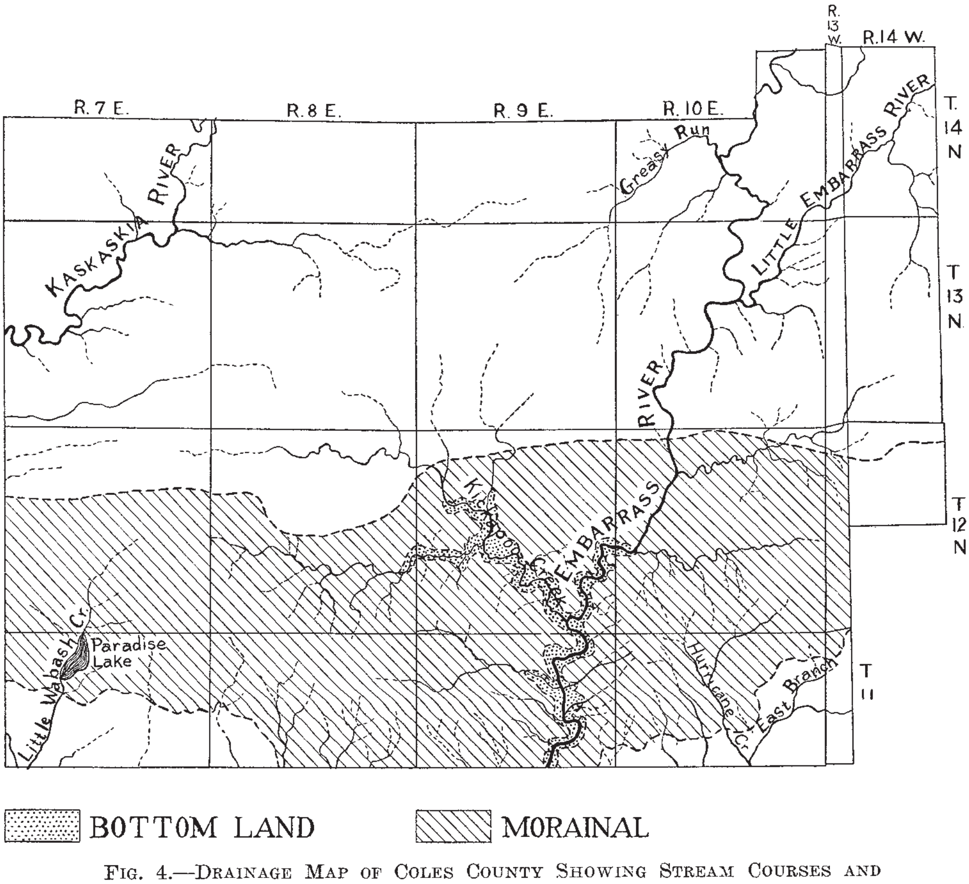

FIG. 4.—DRAINAGE MAP OF COLES COUNTY SHOWING STREAM COURSES AND BOTTOM-LAND AND MORAINAL AREAS

while the topography along the Embarrass river, particularly in the southern part of the county, is strongly rolling. The topography of the terminal morainal region, as well as of the small morainal lobe north of Bushton is in general undulating to gently rolling. Apparently the terminal moraine formed a barrier to the drainage until cut thru by Kaskaskia and Embarrass rivers. It was probably during the time when the ice front was retreating to the north that much of the fine sediment from which the heavy soils of this region were formed was laid down.

Most of the drainage of the county is carried by Embarrass and Little Wabash rivers into Wabash river and thence into the Ohio. Kaskaskia river drains the northwest corner of the county, carrying the water southwest into the Mississippi.

The following altitudes at several points in Coles county are given in feet above sea level: Humbolt, 666 feet; Mattoon, 735; Lerna, 754; Charleston, 654; Ashmore, 682; Oakland, 655.

SOIL DEVELOPMENT

A sufficient length of time has elapsed since the ice age for soils to be developed from the materials deposited by the great ice sheets. In Coles county the material from which the soils were formed is largely the ground-up rock known as till or drift. The drift has been locally reworked by wind and water but there appears to have been but little loess deposited over the county. During the long period of time which has elapsed since the retreat of the last ice sheet, the processes of weathering have been acting on the drift, gradually changing it into soil. The soil features, most easily seen, produced by the weathering processes, are the layers or horizons which make up the soil profile.

The horizons are designated by the letters *A*, *B*, and *C* from the surface down. Each of these horizons is usually made up of two or more parts. A more complete discussion of the meaning and designation of horizons will be found on page 23.

Since the upland dark-colored soils of this region have been occupied, probably continuously, by grass vegetation, relatively large amounts of organic matter have accumulated, resulting in the formation of productive dark-colored soils. The areas adjacent to streams, which have been occupied by timber, are light-colored because of the relative deficiency of the surface soil in organic matter. The bottom-land soils are made up, for the most part, of alluvial material brought down from the uplands of the immediate vicinity. These soils are relatively young or immature and therefore have not developed horizons as have the more mature soils of the upland.

SOIL GROUPS

The soils of Coles county are divided into four groups, as follows:

Upland Prairie Soils, dark colored and usually rich in organic matter, the organic matter having been derived from the decaying roots of the wild prairie grasses which occupied this land for thousands of years.

Upland Timber Soils, those zones along stream courses over which forests grew for a long period of time. These contain in general less organic matter than the prairie soils.

Terrace Soils, including bench lands and second bottoms formed by deposits from flooded streams overloaded with sediment, perhaps at the time of the melting of the glaciers.

Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

TABLE 1.—SOIL TYPES OF COLES COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (300, 900, 1100)			
326, 926, 1126	Brown Silt Loam[1]	214.12	137 037	42.08
320, 920, 1120	Black Clay Loam	87.28	55 859	17.15
1121	Drab Clay Loam	1.94	1 242	.38
328, 928, 1128	Brown-Gray Silt Loam On Tight Clay	8.02	5 133	1.58
330	Gray Silt Loam On Tight Clay	1.91	1 222	.38
		313.27	200 493	61.57
	Upland Timber Soils (300, 900, 1100)			
334, 934, 1134	Yellow-Gray Silt Loam	134.36	85 990	26.40
335, 935, 1135	Yellow Silt Loam	29.07	18 605	5.71
332, 1132	Light Gray Silt Loam On Tight Clay	.19	122	.04
364	Yellow-Gray Sandy Loam	1.02	653	.20
		164.64	105 370	32.35
	Terrace Soils (1500)			
1526	Brown Silt Loam	1.09	698	.22
1560	Brown Sandy Loam	.16	102	.03
1528	Brown-Gray Silt Loam On Tight Clay Over Gravel	.06	38	.01
1536	Yellow-Gray Silt Loam Over Gravel	3.42	2 189	.67
1564	Yellow-Gray Sandy Loam	.07	45	.01
		4.80	3 072	.94
	Swamp and Bottom-Land Soils (1400)			
1454	Mixed Loam	25.91	16 582	5.10
	Water	.22	141	.04
	Total	508.84	325 658	100.00

[1]Including associated types described in the text but not differentiated on the map.

Table 1 gives the area of each soil type in Coles county and its percentage of the total area. It will be observed that 61.57 percent of the county consists of upland prairie, 32.35 percent of upland timber, .94 percent of terrace soils, and 5.10 percent of swamp and bottom-land soils. The accompanying map, appearing in two sections, shows the location and boundary lines of the various soil types.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this Report.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN COLES COUNTY SOILS

Three Depths Represented by Soil Samples

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches, and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches, and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling, we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow, and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore, it is the only stratum which can be greatly changed in composition as a result of adding fertilizing materials.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that it is based on different quantities of soil, as indicated above. The figures for the middle and lower strata must, therefore, be divided by two and three respectively before being compared with each other, or with the figures for the upper stratum.

The data in Tables 2, 3, and 4, showing plant-food content of Coles county soils, are based in part upon analyses of samples taken from surrounding counties.

Wide Range in Organic Matter and Nitrogen

It can be readily seen from Table 2 that there is a wide variation among the different soil types of Coles county with respect to their content of the different plant-food elements in the upper 6⅔ inches of soil. The most striking relationship among these variations is observed with respect to organic carbon

and nitrogen, the quantities of which run parallel from type to type tho the organic-carbon content is usually 10 to 12 times as great as the nitrogen. The relationship between organic carbon and nitrogen is explained by the well-established facts that all soil organic matter (or which organic carbon is the measure) contains nitrogen, and that most of the soil nitrogen—usually 99 percent or more—is present in a state of organic combination; that is, as a part of the organic matter.

The upland prairie soils of Coles county are, for the most part, relatively high in organic matter and nitrogen, while the upland timber soils are fairly low, there being little overlapping in the two groups with respect to these constituents. That is, the greatest amount present in the timber soils is about the same as the least amount found in the prairie types. This difference is noticeable not only in the surface soil, but extends to the middle stratum as well. Yellow Silt Loam and Yellow-Gray Sandy Loam are particularly deficient in organic matter and nitrogen. The former type is subject to excessive erosion, which removes the surface soil with its organic-matter accumulation, while the latter, owing to its porous character, permits rapid oxidation of organic matter.

All of the soils of the county diminish rapidly in their content of both organic matter and nitrogen with increasing depth. This diminution is noticeable in the second stratum, 6⅔ to 20 inches, and is very pronounced in the lower stratum, 20 to 40 inches.

Phosphorus Lower in Light-Colored Soils

The total phosphorus content varies somewhat from type to type. It is noticeably low in the lighter colored upland timber soils and high, on the whole, in the upland prairie types. The greatest amount, 1,840 pounds per acre, is to be found in Black Clay Loam. There is a tendency for the phosphorus content of soils to parallel the organic carbon to some extent, but not closely as does nitrogen. Phosphorus, in contrast with some other elements, is not appreciably removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in plant residues at the expense of underlying strata. Investigations at the Illinois Station have shown that in Brown Silt Loam, for example, about 33 percent of the total phosphorus of the surface soil is organic, and in Black Clay Loam about 37 percent. It is the second stratum (6⅔ to 20 inches) which furnishes most of the phosphorus thus moved upward. Consequently, in the soils of Coles county the phosphorus percentage is generally higher in the surface soil than in the second stratum, and frequently higher than in the lower stratum.

Sulfur Generally Well Supplied

Sulfur, another element used by growing plants, is likewise associated to some degree with organic carbon. This is because a considerable, tho varying, proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of organic matter. The soils of Coles county contain from one-half to three-fourths as much sulfur as phosphorus, the amount in the surface soil ranging from 320 to 1,260 pounds per acre. Like phosphorus, the sulfur content

generally decreases with depth, partly because part of the sulfur is organic, and organic matter decreases with depth, and also partly because organic sulfur is less subject to leaching than calcium sulfate (gypsum), the chief inorganic form found in soils.

The amount of sulfur available to crops is influenced not only by the soil supply, but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water, and consequently is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption, the amount of sulfur thus added to the soil is relatively large. At Urbana during the eight-year period, 1917 to 1924, there was added to the soil by the rainfall an average of 3.5 pounds of sulfur an acre a month. Similar observations have been made in other localities for shorter periods. The precipitation at the various points in the state in a single month has been found to vary from a minimum of three-fourths of a pound to more than ten pounds an acre.

These figures afford some idea of the amounts of sulfur added by rain, and also of the wide variations in amount under different conditions. Considering the amounts which are brought down in rainfall in addition to the soil supply, the facts would indicate that apparently there is little or no need for sulfur fertilizers in Coles county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started on a number of experiment fields in various parts of Illinois.

Potassium Content Relatively Uniform Thruout County

The potassium content of the soil exhibits less variation from type to type than any other element studied. The average amount in the surface soil is approximately 34,000 pounds per acre, and the entire range thru all the types in the county is from a minimum of 27,560 pounds up to 39,100 pounds per acre. The potassium concentration in the soil at different depths likewise shows very little variation.

Wide Variations in Calcium and Magnesium

Soils in general exhibit wide variations in their content of calcium and magnesium, and Coles county is no exception to this rule. In the surface soil, magnesium varies from 3,380 to 13,320 pounds per acre, while calcium varies from 5,000 to 18,900 pounds. Even the higher amount of total calcium noted does not indicate the presence of calcium carbonate (limestone) in the soil. Considerable amounts of calcium are always present, even in acid soils. Most of it is combined with silicic acid to form the complex silicate minerals and, while it serves to keep down the acidity, it may become available to plants so slowly as to make calcium deficiency a limiting factor in their growth. Added lime or limestone supplies readily available calcium in addition to correcting soil acidity.

The very high values for total calcium in the lower stratum of Black Clay Loam and Drab Clay Loam, namely, 118,060 and 73,910 pounds per acre, respectively, are to be attributed to the presence of calcium carbonate (limestone)

in this stratum. Leaching of native calcium carbonate proceeds downward with the result, in Coles county, that it has disappeared from the surface soil of practically the entire area, and has passed down below the 40-inch stratum sampled in the case of most types. Some increase in total magnesium accompanies the high calcium of these carbonate-containing strata. The increases are not great, however, because of the inability of magnesium to exist long in the soil in the form of carbonate. The carbonate of carbonate-containing soils is chiefly calcium carbonate.

In the upland soils variations in the amounts of calcium and magnesium at the different depths give some indication of the movement of these elements in soil formation. In the surface soil the calcium usually exceeds the magnesium in amount, as a result of the preponderance of calcium in the soil-forming materials. As these two bases are carried down in solution, magnesium is more readily absorbed than calcium in the soil mass, so that with increasing depth there is an increasing proportion of magnesium to calcium. This change is most pronounced in the most mature soils such as Light Gray Silt Loam On Tight Clay, where the ratios of magnesium to calcium in the upper, middle and lower strata are, respectively, .93, 1.13, and 2.29. That is, in the surface soil there is slightly less magnesium than calcium. In the second stratum there is slightly more, while in the lower stratum there is about 2⅓ times as much magnesium as calcium. On the other hand, in youthful soils where the leaching has been less intense or less prolonged, the ratio of magnesium to calcium shows little or no increase in the lower levels. For instance, in Black Clay Loam the ratios of magnesium to calcium are, in the three respective strata, .70, .79, and .51. Here the drop in *relative* amount of magnesium in the lower stratum is an expression of the calcium-carbonate accumulation noted above. Thus it will be seen that variations in the processes of soil development may be definitely reflected in the chemical properties of the soil itself.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium-carbonate content or the acidity of a given soil type because, while some samples will contain large amounts of calcium carbonate, others will contain none, but on the other hand will have a lime-requirement due to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point. The numerical average of such values could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made in the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and do give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests, therefore, furnish the basis for some general recommendations which are given in the descriptions of individual types on pages 15

to 22. To have a sound basis for the application of limestone the owner or operator of a farm must usually determine individually the lime requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 31) is pertinent and should be read in this connection.

Supplies of Different Elements Not Proportional to Crop Removal

In the foregoing discussion we have considered mainly the amounts of the plant-food elements in the surface 6⅔ inches of soil, and rather briefly the relative amounts in the two lower strata. We have noted that some of the elements of plant food exhibit no consistent change in amount with increasing depths. Other elements show more or less marked variation at the different levels, the trend of these variations serving in some cases as clues to the relative maturity of different soil types and the processes involved in their development.

By adding together the corresponding figures for all three strata, we have an approximate invoice of the total plant-food elements within the feeding range of most of our field crops, since the major portion of their feeding range is included in the upper 40 inches. One of the most striking facts brought out of this consideration of the data is the great variation within a given soil type in the relative abundance of the various elements present as compared to the amounts removed by crops. In one of the important types in the county, Brown Silt Loam, Upland, we find that the total quantity of nitrogen in all three strata is 14,730 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus is approximately one-third as much, or 4,850 pounds, but this amount is equivalent to the phosphorus in about twice as much corn. In the surface stratum, however, which is the zone of most intensive crop feeding, we find the relative amounts of nitrogen and phosphorus more nearly in accord with the rate of removal of these elements by crops. Here the nitrogen is equivalent to 4,700 bushels of corn, and the phosphorus to 6,000 bushels, or only one-third more than the nitrogen equivalent.

Other types show marked contrast to Brown Silt Loam with respect to total soil content in relation to rate of removal by crops. However, in most soils, except those which are peaty, phosphorus is more abundant than nitrogen when considered in terms of crop equivalents rather than absolute amounts of the respective elements.

Limitations of Chemical Analysis of the Soil Not Always Appreciated

The foregoing discussion should not be taken to mean that it is possible to predict how long any certain soil could be cropped under a given system before it would become exhausted. Nor do the figures alone indicate the immediate procedure to be followed in the improvement of a soil. It must be kept in mind that the *amount* of plant food shown to be present is not the sole measure of the ability of a soil to produce crops. The *rate* at which these elements are liberated from insoluble forms and converted to forms that can be used by growing plants is a matter of at least equal importance, as explained on page 29, and is not necessarily proportional to the total stocks present. One must know, therefore, how to cope with the peculiarities of a given soil type, if he is to secure the full

benefit from its stores of the plant-food elements. In addition, there are economic factors that must be taken into consideration, since it is necessary for one to decide at how high a level of productivity he can afford to maintain his soil.

The chemical soil analysis made in connection with the soil survey is seen to be of value chiefly in two ways. In the first place it reveals at once outstanding deficiencies or other chemical characteristics which alone would affect its productivity to a marked extent, or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual

TABLE 2.—COLES COUNTY SOILS: PLANT-FOOD ELEMENTS IN UPPER SAMPLING STRATUM ABOUT 0 TO 6⅔ INCHES[1]

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300, 900, 1100)							
326, 926, 1126	Brown Silt Loam	54 200	4 700	1 030	660	35 120	7 920	9 690
320, 920, 1120	Black Clay Loam	75 520	7 220	1 840	1 260	32 490	13 320	18 900
1121	Drab Clay Loam	54 280	5 280	1 490	950	39 100	12 290	16 090
328, 928, 1128	Brown-Gray Silt Loam On Tight Clay	34 580	3 280	1 020	700	30 270	4 810	6 560
330	Gray Silt Loam On Tight Clay	22 710	2 640	750	320	33 490	4 830	5 510
	Upland Timber Soils (300, 900, 1100)							
334, 934, 1134	Yellow-Gray Silt Loam	25 400	2 280	770	420	35 620	5 860	6 470
335, 935, 1135	Yellow Silt Loam	17 430	1 560	590	420	35 890	4 850	5 000
332, 1132	Light Gray Silt Loam On Tight Clay	20 180	2 080	840	400	35 080	6 320	6 820
364	Yellow-Gray Sandy Loam[2]	......	......	......	......	......	......	......
	Terrace Soils (1500)							
1526	Brown Silt Loam	39 500	3 840	940	600	27 560	7 020	11 500
1560	Brown Sandy Loam	39 040	3 960	980	620	37 320	4 800	10 480
1528	Brown-Gray Silt Loam On Tight Clay Over Gravel	19 740	2 100	1 060	540	31 940	3 380	5 060
1536	Yellow-Gray Silt Loam Over Gravel	25 010	2 460	1 000	480	34 550	3 780	6 620
1564	Yellow-Gray Sandy Loam	13 800	1 370	830	340	30 140	3 630	5 930
	Bottom-Land Soils (1400)							
1454	Mixed Loam[3]	......	......	......	......	......	......	......

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]Samples from neighboring counties were used in these averages.
[2]No samples were obtained for analysis.
[3]Analytical results are not included for Mixed Loam because of the heterogeneity of this type.

are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. An example of the direct use of the results of chemical investigations is the marked shortage of potassium in peat soils associated with the need for potassium fertilizers; another example is the determination of the lime need of soils by chemical tests. It is quite probable that the results of chemical soil analyses are frequently misused by attempting to interpret small differences in the amount of a certain plant-food element as indicative of similar differences in the fertilizer need. For example, differences of 100 or 200 pounds of phosphorus per acre in soils containing 1,000 pounds or thereabout in the surface soil should not be considered as of any agricultural significance. Again, 100 pounds to the acre of active organic nitrogen added by plowing down a clover crop may be of more

TABLE 3.—COLES COUNTY SOILS: PLANT-FOOD ELEMENTS IN MIDDLE SAMPLING STRATUM, ABOUT 6⅔ TO 20 INCHES[1]

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300, 900, 1100)							
326, 926, 1126	Brown Silt Loam	69 510	6 280	1 660	1 130	70 750	18 950	17 700
320, 920, 1120	Black Clay Loam	70 750	6 810	2 630	1 500	67 860	27 750	34 920
1121	Drab Clay Loam	63 280	6 490	2 540	1 350	79 040	27 040	29 700
328, 928, 1128	Brown-Gray Silt Loam On Tight Clay	32 780	3 600	1 550	850	63 650	12 740	11 660
330	Gray Silt Loam On Tight Clay	18 920	2 510	1 200	240	61 430	15 450	12 480
	Upland Timber Soils (300, 900, 1100)							
334, 934, 1134	Yellow-Gray Silt Loam	19 530	2 300	1 310	510	75 190	20 640	12 850
335, 935, 1135	Yellow Silt Loam	15 480	1 750	1 250	600	75 390	20 550	8 550
332, 1132	Light Gray Silt Loam On Tight Clay	17 040	1 920	1 160	500	73 000	15 960	14 240
364	Yellow-Gray Sandy Loam[2]							
	Terrace Soils (1500)							
1526	Brown Silt Loam	33 600	3 480	1 840	600	79 360	12 680	20 960
1560	Brown Sandy Loam	33 360	3 480	1 520	480	71 880	10 080	16 640
1528	Brown-Gray Silt Loam On Tight Clay Over Gravel	15 160	2 080	2 040	680	66 760	11 960	9 960
1536	Yellow-Gray Silt Loam Over Gravel	17 880	2 520	2 000	420	77 640	10 000	12 280
1564	Yellow-Gray Sandy Loam	11 100	1 700	1 760	500	63 540	12 200	10 140
	Bottom-Land Soils (1400)							
1454	Mixed Loam[3]							

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Samples from adjoining counties were used in these averages.
[2]No samples were obtained for analysis.
[3]Analytical results are not included for Mixed Loam because of the heterogeneity of this type.

importance to the succeeding crop than a difference in soil composition of 1,000 pounds an acre of nitrogen.

Chemical Studies Important in Soil Investigations

The second function of soil analysis is as an aid in the scientific study of soils from many angles, the ultimate aim of which is, of course, the more economical utilization of the soil for efficient crop production. Not only do chemical studies aid in determining the processes involved in soil development under natural conditions, but also in determining the effects of different soil management and fertilizing practices upon the soil, and upon the utilization by crops of the plant-food elements involved.

TABLE 4.—COLES COUNTY SOILS: PLANT-FOOD ELEMENTS IN LOWER SAMPLING STRATUM, ABOUT 20 TO 40 INCHES[1]

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300, 900, 1100)							
326, 926, 1126	Brown Silt Loam	31 790	3 750	2 160	1 060	108 220	41 860	31 130
320, 920, 1120	Black Clay Loam	32 690	3 760	3 200	1 440	102 810	60 170	118 060
1121	Drab Clay Loam	36 890	4 260	3 080	1 340	114 260	57 720	73 910
328, 928, 1128	Brown-Gray Silt Loam On Tight Clay	27 350	3 200	2 430	740	99 280	32 420	31 880
330	Gray Silt Loam On Tight Clay	15 780	2 600	2 120	300	95 020	30 680	20 220
	Upland Timber Soils (300, 900, 1100)							
334, 934, 1134	Yellow-Gray Silt Loam	16 140	2 420	1 980	1 020	121 320	49 870	30 530
335, 935, 1135	Yellow Silt Loam	13 380	2 140	2 000	660	123 680	36 680	15 720
332, 1132	Light Gray Silt Loam On Tight Clay	22 620	2 820	1 920	800	109 560	42 600	18 600
364	Yellow-Gray Sandy Loam[2]	......	......	......	......	......	......	......
	Terrace Soils (1500)							
1526	Brown Silt Loam	45 840	3 660	1 980	1 020	122 580	19 200	24 420
1560	Brown Sandy Loam	21 060	2 400	2 940	900	103 920	12 360	18 480
1528	Brown-Gray Silt Loam On Tight Clay Over Gravel	12 540	2 580	2 460	1 020	100 560	26 640	24 780
1536	Yellow-Gray Silt Loam Over Gravel	13 080	2 580	2 910	690	109 290	24 720	19 560
1564	Yellow-Gray Sandy Loam	10 170	1 980	2 310	600	88 830	20 460	17 220
	Bottom-Land Soils (1400)							
1454	Mixed Loam[3]	......	......	......	......	......	......	......

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Some samples from neighboring counties were used in these averages.
[2]No samples were obtained for analysis.
[3]Analytical results are not included for Mixed Loam because of the heterogeneity of this type.

DESCRIPTION OF SOIL TYPES

The soil map of Coles county upon which this report is based was completed in 1921. Since that time there have been some changes in the mapping of soils. A soil map of the county made at this time would differ from the map completed in 1921, chiefly in showing a few more soil types. In the following description of each type will be found a brief discussion of any change which would be made in mapping it at the present time, and with these explanations the reader should get a better idea of the various soil types shown on the map.

UPLAND PRAIRIE SOILS

The upland prairie soils of Coles county occupy 313.27 square miles, or 61.57 percent of the area of the county.

The dark color of prairie soils is due to the accumulation of organic matter, derived very largely from the fibrous roots of prairie grasses that grew on this land for centuries. The stems and leaves of the grasses were in part burned by prairie fires or were lost in part thru decay, so that they actually added little organic matter to the soil; however, the protection afforded by this mat of constantly renewed, decaying material was of importance in retarding the decay of the roots. From a sample of virgin bluestem sod, one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of 7 inches may contain as high as 13½ tons of roots.

Brown Silt Loam (326, 926, 1126)

About 42 percent, or over 200 square miles, of the area of Coles county is shown on the accompanying map as Brown Silt Loam. With advancing knowledge of soil classification, however, it is now possible to recognize within this area at least four and possibly five distinguishable soil types. Four of these will be described. The fifth occurs in portions of Piatt, Macon, Moultrie, and Coles counties, but has not as yet been studied sufficiently to justify considering it established. The four types now differentiated are Brown Silt Loam On Clay, Brown Silt Loam, Brown Silt Loam On Drift, and Light Brown Silt Loam On Drift. These types all occur on the areas shown on the map as Brown Silt Loam. Their occurrence bears a rather definite relation to topography, as will appear from the descriptions which follow.

Brown Silt Loam On Clay. This type occurs on nearly level areas. It was formed under conditions of intermittently poor drainage, which resulted in an accumulation of considerable fine-textured material in the subsoil. Associated with this fine texture and plasticity of the subsoil, or B horizon, is a gray color showing a lack of free air movement. The surface soil, or A_1 horizon, is dark brown in color and is in some places rather heavy for a silt loam. The subsurface or A_2 horizon is heavier than the A_1 and lighter in color.

Management.—This type, even tho it has a heavy subsoil, will underdrain satisfactorily. In tiling, the strings of tile should be placed closer together than for any of the other types mapped as Brown Silt Loam. Regular additions of fresh organic matter should be provided, for otherwise this soil will gradually be-

come more difficult to work. Limestone is needed for sweet clover or alfalfa, tho in light applications. The lowest portions of the type may need no limestone and occasionally small alkali spots occur. The harmful effects of the alkali may be corrected by applying 75 to 100 pounds of potash to the acre for corn. This type is similar to the soil on the Hartsburg and Aledo experiment fields. The results from these two fields are in agreement in indicating the value of manure on all the crops of the rotation; the value of residues, particularly for corn; and the failure of rock phosphate as used on these fields, particularly in the manure system, to cause sufficient increase in yields to justify advising its indiscriminate use on this soil type. If alfalfa is to be seeded, the application of 1,000 pounds of rock phosphate, or 500 pounds of superphosphate an acre would be advisable, or, if wheat is to be seeded to sweet clover, it would be advisable to make a trial application of either of these materials after plowing but before working down the wheat seed bed. The reader is referred to page 34 for a further discussion of the phosphate problem.

Brown Silt Loam. This type occurs on undulating topography. It has good surface drainage and underdrainage. The profile is friable and easily permeable to roots as well as to water. This type is not extensively developed in Coles county. Tho it is not strongly acid, a heavier application of limestone is needed than on the preceding type because it is more uniformly acid. The surface soil, or A_1 horizon, is brown in color and, unlike the preceding type, does not tend to be too heavy for a true silt loam. The subsurface, or A_2 horizon, is distinctly yellowish and is not much heavier than the A_1. The subsoil, or B horizon, is brownish yellow with some gray mottling present; it is a clay loam but is friable and only medium plastic.

Management.—This type is similar to the soil on the Kewanee experiment field. The results from this field (page 49) show a good response to manure alone and to residues and lime in combination. Where lime was used in addition to manure, an additional increase in yield was secured, but the increase was not so large as where lime was used in addition to residues. This behavior indicates that manure satisfies in part the same deficiency that lime satisfies on this medium-acid soil. The returns from the use of rock phosphate on this field are not such as to justify its unqualified recommendation. This is particularly true in the manure system. Where green manures were the source of nitrogen and organic matter, rock phosphate gave just about sufficient increase in yield to pay for its cost when used at the rate of one ton an acre once in the rotation. The Bloomington experiment field is located in part on this same type of soil. The results from this field (page 51) show excellent returns for phosphorus and lead to the recommendation that one of the phosphates be given a trial for wheat. The reader is referred to the discussion of these materials on page 34.

Brown Silt Loam On Drift. This type occurs on undulating to gently rolling topography and is found extensively developed thruout most of the county where dark-colored soils occur. The entire profile is similar in color to that of the last type described, but differs from it in character of the soil material,

particularly in having much more sand and gravel in the lower horizons. The surface soil, or A_1 horizon, to a depth of about 8 inches is brown in color and a silt loam in texture. It frequently contains a number of chert and other rock fragments. The A_2 horizon is a yellowish brown silt loam containing some rock fragments and extends to a depth of about 18 or 20 inches. The B horizon is a medium-mottled, dark yellow, sandy and gravelly clay, medium compact and slightly plastic. The C horizon is a yellow, sandy, gravelly clay loam, fairly friable, and not much compacted.

Management.—Brown Silt Loam On Drift is thought to be very similar in management requirements to Brown Silt Loam, the last type described. It differs in being slightly more acid, somewhat lower in organic matter, and more subject to erosion.

Light Brown Silt Loam On Drift. This type differs from Brown Silt Loam On Drift in being much lower in organic matter, more acid, and subject to serious erosion. The land is all tillable, but is spoken of by farmers as being a thin soil. This type occurs only on the more pronounced slopes of the two morainal ridges shown on the soil map, one extending as a broad belt across the southern part of the county and the other occurring as a small lobe north of Bushton. The surface, or A_1 horizon, is light brown or reddish brown in color and in places contains considerable glacial gravel. The subsurface, or A_2 horizon, is yellowish brown in color and contains more gravel than the surface. The subsoil, or B horizon, is gravelly glacial drift, somewhat compact but not plastic. The thickness of the various horizons varies because of differences in the rate of erosion on different areas. Carbonates commonly occur at a depth of 40 to 50 inches.

Management.—This type is less productive than any of those previously described. The soil needs frequent additions of fresh leguminous organic matter. It is more acid than less rolling land, and it must be handled carefully if erosion is to be reduced below the point where it is very harmful. The trial of either rock phosphate or superphosphate for wheat which is to be seeded to clover is advised for this soil.

Black Clay Loam (320, 920, 1120)

Over 87 square miles of Black Clay Loam are mapped as such in Coles county. However, this Black Clay Loam as mapped is now recognized to include four distinguishable types. These four types will not be described as they do not differ in topography so strikingly as do the separations noted for Brown Silt Loam and are therefore less easily recognized. For this reason the following generalized description of the type as it is mapped will be given instead of each type as now differentiated.

The A_1 horizon is 10 to 12 inches deep, and is a dark brown to black clay loam. The A_2 horizon usually extends to a depth of about 20 inches, is drabbish black in color, and is somewhat heavier than the A_1 horizon. It usually contains small yellow spots and in the lighter portions of the type is distinctly yellow

instead of drabbish black. The *B* horizon in the heavier portions of the type is a gray or heavily mottled, compact, and plastic clay, while in the lighter portions it is a strongly mottled yellow, compact, medium-plastic clay or clay loam.

Management.—It should be noted that alkali spots occur in Black Clay Loam and that potash treatment is needed on some of them because of the high concentration of soluble salts. Lime is generally not needed on this soil but regular additions of fresh organic matter should be provided for as an aid in maintaining a good physical condition. The use of phosphate is not likely to prove profitable on this soil as is indicated by the results from the Minonk and Hartsburg experiment fields. If no manure is available it might be well to try rock phosphate at the rate of about 1,000 pounds an acre, or superphosphate at the rate of about 250 pounds an acre, for wheat. The summarized results from the Minonk and Hartsburg fields are given on pages 55 and 56.

Drab Clay Loam (1121)

Drab Clay Loam is a minor type in Coles county, occurring only in two areas in the north-central part of the county. It is a soil formed under poor drainage conditions. The reason for its drab color instead of black is not entirely clear but seems to be associated with a set of conditions which limited the growth of the grasses.

The surface, or A_1 horizon, is about 7 inches thick and is usually a drabbish black clay loam or silty clay loam. The subsurface, or A_2 horizon, is somewhat lighter in color than the surface, usually being drabbish brown. The subsoil, or *B* horizon, is drab or yellowish drab containing reddish brown spots. It is heavy but will underdrain.

Management.—Drab Clay Loam is usually not acid and in places is alkaline. It is relatively low in organic matter. It also requires thoro underdrainage. Much has been done by the construction of dredge ditches and the laying of tile to take care of the excess water on this soil. Alkali spots are common and lime concretions and marly material are often found within forty inches of the surface.

Brown-Gray Silt Loam On Tight Clay (328, 928, 1128)

Brown-Gray Silt Loam On Tight Clay occurs chiefly in the southeast and southwest corners of the county and south and east of Ashmore. The total area occupied by this type is only about 8 square miles. This type is characterized by a grayish brown surface, or A_1 horizon, a gray subsurface, or A_2 horizon, and a brown, highly plastic, and compact subsoil, or *B* horizon. The *B* horizon is mottled with yellow, reddish brown, and gray.

Management.—The feature of Brown-Gray Silt Loam On Tight Clay which is of most importance from the standpoint of soil management is the impervious *B* horizon which occurs at a depth varying from about 16 to 28 inches. Underdrainage is not effective in removing excess water, because water passes thru the plastic material too slowly. Furrows and open ditches must be depended on for drainage. Crops are more subject to injury from drouth on this soil than on one in which the movement of water and penetration of roots are good. This

soil is acid. Following the application of limestone, good sweet clover crops may be grown, and this in turn makes it possible to grow satisfactory corn crops except in seasons when the rainfall is not well distributed. This soil type is probably better suited to small grains, soybeans, cowpeas, and clover than to corn.

Gray Silt Loam On Tight Clay (330)

Gray Silt Loam On Tight Clay is a minor type in Coles county, occupying a total area of less than two square miles. It is found just south of the moraine in the southwest and southeast corners of the county. This type is similar in some respects to Brown-Gray Silt Loam On Tight Clay, but is a poorer soil. The surface, or A_1 horizon, is about 7 inches deep and is gray in color. The subsurface, or A_2 horizon, is light gray in color. This stratum is friable and is easily penetrated by water and roots but has a low water-holding capacity. The subsoil, or B horizon, is heavy and plastic and highly impervious to roots and to water. It lies at a depth of about 18 inches, and is usually from 8 to 12 inches in thickness. Below this impervious layer, a fairly friable material occurs.

Management.—Gray Silt Loam On Tight Clay is strongly acid and no improvement in its productivity can be expected until limestone has been applied and nitrogen and fresh organic matter provided thru manure or thru the growing of legumes, preferably sweet clover. Drainage must be taken care of by open ditches and furrows since the impervious subsoil makes the use of tile impossible.

UPLAND TIMBER SOILS

Nearly one-third of the area of Coles county is occupied by light-colored or timber soils. These soils are usually characterized by a yellow or yellowish gray color, which is due to the low organic-matter content. This lack of organic matter has been caused by the long-continued growth of forest trees. As the forests invaded the prairies, the following effects were produced: the shading of the trees prevented the growth of grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils; and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed or were destroyed by forest fires.

The timbered soils are of two kinds, the undulating and the eroded.

Yellow-Gray Silt Loam (334, 934, 1134)

Yellow-Gray Silt Loam, covering about 134 square miles as mapped in Coles county, includes in reality several light-colored soil types. The flat, nearly level areas have a relatively impervious, gray subsoil, while the better-drained areas have a sufficiently open subsoil for good underdrainage and the color is yellowish, or even reddish if the slope is strong. A detailed profile description for Yellow-Gray Silt Loam as mapped in this county cannot be written since, as above stated, several types are included under this name.

Management.—The nearly level portions of this type are more acid than the undulating and rolling portions and are naturally poorly drained. Lime is a

general requirement, tho the amount needed varies not only with the constitutional requirements of the soil but also with other factors, as for example, with the length of time and intensity with which a field has been farmed. Leguminous organic matter is also a general requirement and provision should be made for the regular growth of clover, preferably sweet clover, on any of this type which is farmed. Phosphate should give profitable returns on the undulating portions of this type, particularly if used for wheat. Either rock phosphate or superphosphate may be tried, the former at the rate of about 1,000 pounds an acre and the latter at the rate of about 250 pounds.

Yellow Silt Loam (335, 935, 1135)

Yellow Silt Loam occurs in Coles county along Embarrass river and its tributaries. Some areas are found along streams in other portions of the county, but they are small in extent. The total area of this type in Coles county aggregates about 29 square miles. A large percentage of the type is suitable only for pasture, timber, or orchard because of its steep topography. The areas along the Little Embarrass in Township 14 North, Range 14 West, are not sufficiently steep to prevent their use for general farming. The character of the soil occupying these slopes varies greatly depending on local variations in the material from which the soil is formed and on the rapidity of erosion.

Light Gray Silt Loam On Tight Clay (332, 1132)

Light Gray Silt Loam On Tight Clay occupies a total of only 122 acres in Coles county. It is a very poor soil and it is probably unwise at the present time to undertake its improvement. Further information regarding this soil may be had by correspondence.

Yellow-Gray Sandy Loam (364)

Yellow-Gray Sandy Loam occupies a total area of about one square mile in Coles county and is found along the Little Wabash in the southwestern part of the county. This soil was formed from material carried down from the moraine at the north by the Little Wabash and deposited in its present location by the wind. It is dune-like in topography and varies somewhat in its characteristics because of the assorting action of the wind.

The surface, or A_1 horizon, is gray in color. It varies in depth but is usually not shallower than 5 inches nor deeper than 7 inches. The subsurface, or A_2 horizon, is light gray, and the subsoil, or B horizon, is drabbish gray and is medium compact but friable. The sand content of this soil is not so high as is common for the type except on the ridges.

Management.—Yellow-Gray Sandy Loam is acid and is deficient in nitrogen and organic matter. Each field which is to be improved should be tested in detail for acidity and then sufficient limestone applied so that sweet clover may be grown. If sweet clover is given a regular place in the rotation and used primarily as a soil-improving crop, this soil should produce satisfactory yields.

TERRACE SOILS

Relatively small areas of terrace soils occur in Coles county. The terraces were built up, for the most part, during and immediately following the Glacial period when overloaded and flooded streams deposited an immense amount of material in their channels. Later as the streams diminished in size or cut their channels deeper, new bottoms were developed, leaving the old flood plains above overflow, thus forming terraces. It was upon these plains that the terrace soils developed.

Brown Silt Loam (1526)

Brown Silt Loam, Terrace, occurs as small areas along the lower course of Embarrass river and totals slightly more than one square mile. It differs, so far as is known, in no important particular from Brown Silt Loam, Upland. The reader is referred to the discussion of the latter type for suggestions regarding the management of this soil (page 16).

Brown Sandy Loam (1560)

Brown Sandy Loam occurs on terraces in a few small areas along Embarrass river. It has a total area in Coles county of only about one hundred acres. Information regarding this soil and suggestions for its management may be had by writing to the Agricultural Experiment Station.

Brown-Gray Silt Loam On Tight Clay Over Gravel (1528)

The terrace type Brown-Gray Silt Loam On Tight Clay Over Gravel differs in no essential from the corresponding upland type, Brown-Gray Silt Loam On Tight Clay, in this corner of the county except that it is underlain at a depth of 5 to 6 feet by a stratum of gravel. This gravel stratum might afford an outlet for vertical drainage.

Yellow-Gray Silt Loam Over Gravel (1536)

Yellow-Gray Silt Loam Over Gravel is the most extensive terrace type in Coles county. It occupies a total area of about 3½ square miles but occurs only in small areas and is found along both the Kaskaskia and Embarrass rivers. It does not differ materially from the well-drained Yellow-Gray Silt Loam, Upland. The reader is referred to this latter type (page 19) for the description of this terrace soil and suggestions for its management.

Yellow-Gray Sandy Loam (1564)

Yellow-Gray Sandy Loam, Terrace, occupies a total area of only 45 acres in Coles county. It differs from Yellow-Gray Sandy Loam, Upland, in method of formation but not in soil character. The reader is asked to refer to the discussion of the upland type (364) for suggestions regarding the management of this terrace type.

BOTTOM-LAND SOILS

Bottom-land soils, as the name implies, are those found along the stream bottoms. In Coles county, only one type is included in this group.

Mixed Loam (1454)

Mixed Loam as it occurs in Coles county is good agricultural land and is, in large part, cropped. Corn is not generally grown because of overflow. Mixed Loam varies in texture and in other soil characters because of local differences in the velocity of the running water in which the sediment making up the soil was deposited.

Management.—The diversity of Mixed Loam calls for different tillage methods. In places where the soil is heavy, care must be used not to puddle the soil. The soil is not acid because of frequent overflow, and needs only good tillage to produce good corn crops.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as *A*, *B*, and *C* are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the *A* horizon.

C designates the layer lying below the *B* horizon and in which the material has been less affected by the weathering processes.

Frequently differences within a stratum or zone are discernible, in which case it is subdivided and described under such designations as A_1 and A_2, B_1 and B_2.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made wherever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their respective index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoian moraines,* including the moraines of the Illinoian glaciations
300 *Lower Illinoian glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoian glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoian glaciation,* covering about fourteen counties northwest of the middle Illinoian glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoian
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation

1000 *Late Wisconsin moraines*, including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation*, covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation*, lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands*, formed by material derived from the Illinoian or older glaciations
1400 *Late river-bottom and swamp lands*, formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces*, bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits*, formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the remainder of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoian glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to the last of November. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction.

FIG. 5.—EXAMINING THE SOIL PROFILE

Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development in road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil

management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

At least ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed

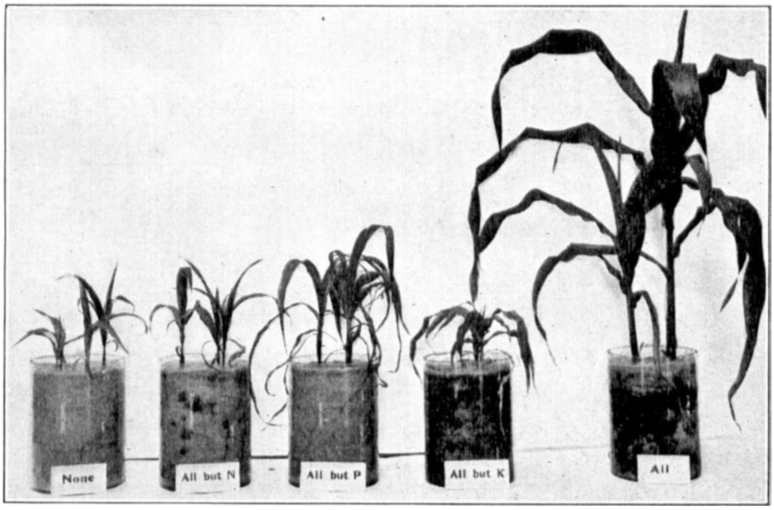

FIG. 6.—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw......	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs.........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain........	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw.........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay........	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed......	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay......	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay........	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants are dependent upon the soil for the other elements, and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.
[2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering

bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4 have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

The nitrogen problem is one of foremost importance in American agriculture. There are four reasons for this: nitrogen is becoming increasingly deficient in most soils; its cost when purchased on the open market is often prohibitive; it is removed from the soil in large amounts by crops; and it is readily lost from soils by leaching. A 50-bushel crop of corn requires about 75 pounds of nitrogen for its growth; and the loss of nitrogen from soils by leaching may vary from a few pounds to over one hundred pounds an acre in a year, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about 69 million pounds of atmospheric nitrogen. Leguminous plants such as clover are able, with the aid of certain bacteria, to draw upon the inexhaustible supply of air nitrogen, utilizing it in their food requirements. In so doing these leguminous plants, thru the decay of their own

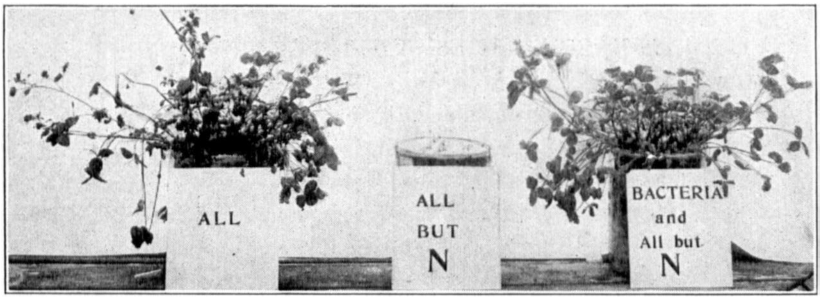

FIG. 7.—LEGUMES CAN OBTAIN THEIR NITROGEN FROM THE AIR

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

tissues, add to the soil nitrogen that has been taken from the air and transformed into food material that can be assimilated by other kinds of crops that follow.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named.

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

Different soil types display great variation in phosphorus content. In Illinois soils a range from 320 to 4,900 pounds an acre has been found in the surface 6⅔ inches, depending mainly on the origin of the soil.

The removal of phosphorus by continuous cropping slowly reduces the amount of this element available for crop use unless its addition is provided for by natural means such as overflow, or by agricultural practices such as the addition of phosphatic fertilizers and the use of rotations in which deep-rooting leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different phosphorus-containing materials that are used as fertilizers. The more important of these are rock phosphate, superphosphate, bone meal, and basic slag.

Rock Phosphate.—Rock phosphate is a mineral substance found in vast deposits in certain regions. A good grade of the rock should contain 12 to 15 percent of the phosphorus element. The rock should be ground to a powder fine enough to pass thru a 100-mesh sieve, or even finer.

Superphosphate.—Superphosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. By further processing, different concentrations are produced. The most common grades of superphosphate now on the market contain respectively 7, 8¾, and 10½ percent of the element phosphorus, and even more highly concentrated products containing as high as 21 percent are to be had. In fertilizer literature the term phosphorus is usually expressed as "phosphoric acid" (P_2O_5) rather than the element phosphorus (P), and the chemical relation between the two is such as to make the above figures correspond respectively to 16, 20, 24, and 48 percent of phosphoric acid. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food. In general, phosphorus in superphosphate is considered to be more readily available for absorption by plants than that of raw rock phosphate.

Bone Meal.—Prepared from the bones of animals, bone meal appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen. If the material is purchased only for the sake of the phosphorus, the cost of the nitrogen represents a useless expense. Steamed bone meal is prepared by extracting most of

the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate, containing about 10 to 12 percent of the element phosphorus and about 1 percent of the element nitrogen.

Basic Slag.—Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore tends to influence the soil reaction in the direction of reducing soil acidity.

Comparative Value of Different Forms of Phosphorus.—Obviously the carrier of phosphorus that gives the most economical returns, considered from all standpoints, is the best one to use. Altho this matter has been the subject of much discussion and investigation, the question remains unsettled. The fact probably is that there is no single carrier that will prove the most economical under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

The relative cheapness of raw rock phosphate as compared with the treated material, superphosphate, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in the form of rock than in the form of superphosphate, the ratio being, under present market conditions, roughly speaking 3½ to 1; that is to say, a dollar will purchase about three and a half times as much of the phosphorus element in the form of rock phosphate as in the form of superphosphate, and this is an important consideration if one is interested in building up a phosphorus reserve in the soil.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using superphosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, the silt loams and clay loams, are well stocked with potassium, altho it exists mainly in a very slowly soluble form. Many field experiments in various sections of Illinois during the past twenty-five years have shown little or no response to the application of potassium in the production of our common grain and hay crops. On the light-colored soils of southern Illinois, however, where stable manure has not been employed, potassium has been applied, with profit, the benefit appearing mainly in the corn crop.

Peat soils are usually low in potassium content. It has frequently been demonstrated in field experiments located on peat land that the difference between success and failure in raising crops depends upon the application of a potash fertilizer.

Potassium has proved beneficial also on the so-called "alkali" spots occurring on certain soil types that are rather high in organic matter, including peat and very dark-colored sandy, silt, and clay loams. The potassium salts in this case appear to exert a corrective influence over what seems to be an unbalanced plant-food condition caused by an excess of nitrate in the soil.

Potassium fertilizer may be procured in the form of one of its salts, such as chlorid, sulfate, or carbonate of potassium, and any of these materials may be applied, where needed, at the rate of 50 to 150 pounds an acre, according to the method of distribution. For our most common crops about the only basis for choosing among these forms is the matter of price, taking into consideration the potassium content. Kainit is another substance containing potassium, but it is combined with magnesium in the form of a double salt. It is therefore less concentrated than the salts mentioned, and so should be applied in larger quantities. An application of about 200 pounds or more of kainit to the acre is suggested.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic

matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If trampled too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the corn is planted. Whether the crop be corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices of produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the best adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)
Sixth year —Clover, or clover and grass

In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed; or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

The two following rotations are suggested as especially adapted for combating the corn borer:

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Wheat (with alfalfa)
Sixth Year —Alfalfa

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)
Fifth year —Clover

First year —Corn
Second year —Soybeans
Third Year —Corn
Fourth year —Wheat (with legume)
Fifth year —Legume

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field rotating over all fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year	—Corn	*First year*	—Wheat or oats (with clover)
Second year	—Oats or wheat (with clover)	*Second year*	—Corn
Third year	—Clover	*Third year*	—Cowpeas or Soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year	—Oats or wheat (with sweet clover)
Second year	—Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute barley or rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover, or it may include alfalfa used as a biennial. The mixing of alfalfa with clover seed for a legume crop is a recommendable practice. In connection with livestock production it may be desirable to mix grass with the clover for pasture or hay. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to Those Occurring in Coles County)

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various soil types. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on soil types described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to forty acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with each crop represented every year.

Farming Systems

On most of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system but certain modifications have been introduced in recent years, as explained in the descriptions of the respective fields.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots at the beginning was usually standardized according to a rather definite system. With advancing experience, however, new problems arose calling for new experiments, so that on most of the fields plots have been divided and a portion given over to new systems of treatment, at the same time maintaining the original system essentially unchanged from the beginning.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—Limestone has usually been applied at the rate of 4 tons an acre as an initial application, and 2 tons an acre every four years thereafter until a considerable excess has accumulated in the soil. Rock phosphate has been applied at the rate of one ton an acre at the beginning, followed by an annual acre-rate of 500 pounds applied once in the rotation until a considerable excess has accumulated. Potassium has been applied usually in the form of 200 pounds of kainit a year. When kainit was not available, owing to conditions brought on by the World War, potassium carbonate was used.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated. (sP = superphosphate, bP = bone meal, rP = rock phosphate, slP = slag phosphate)
K = Potassium (usually in the form of kainit)
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

THE ALEDO FIELD

An experiment field representing the soil type Brown Silt Loam On Clay is located in Mercer county just west of Aledo. This field has been in operation since 1910. From its physical aspects this field should be well adapted to experimental work, the land being unusually uniform in topography and in soil profile.

There are two general systems of plots and they are designated as the major and the minor systems. The major system comprizes four series made up of 10 plots each. The plots were handled substantially as described for standard treatment until 1918, when it was planned to harvest the first crop of

red clover on the residues plots for hay and to plow down the second crop if no seed were formed. In 1921 the return of the oat straw was discontinued. In 1923 the rotation was changed to one of corn, corn, oats and wheat. In this rotation it was planned to seed hubam clover in the oats on all plots, for use as hay or for soil improvement, and common sweet clover in the wheat on the residues plots for use as a green manure. Since this change, no residues except cornstalks and the green manure have been returned to the residues plots. The limestone applications were temporarily abandoned in 1923 after the different series had received 7½ to 9 tons an acre and no more will be applied until a need for lime appears. The phosphate applications were evened up to a total of 4 tons an acre in 1924, and no more will be applied for some time at least.

A summary of the results, showing the average annual yields obtained for the period beginning when complete soil treatment came into sway is given in Table 7. Comparisons in terms of crop increases, intended to indicate the effect of the different fertilizing materials applied is shown in the lower section of the table.

In looking over these results, one may observe first the beneficial effect of animal manure on all crops but especially on corn. This suggests the advisability of carefully conserving and regularly applying all stable manure. Resi-

TABLE 7.—ALEDO FIELD: SUMMARY OF CROP YIELDS

Average Annual Crop Yields 1912-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover	Soybeans[1]	Stubble Clover: Sweet clover	Stubble Clover: Hubam[2]
		14 crops	*23 crops*	*16 crops*	*6 crops*	*3 crops*	*2 crops*	*2 crops*
1	0	29.9	56.0	58.6	(2.21)	(1.60)	....	....
2	M	35.1	69.9	65.7	(2.74)	(1.63)	....	....
3	ML	35.5	73.5	68.5	(3.12)	(1.60)	....	(1.12)
4	MLP	37.2	74.7	69.5	(3.05)	(1.61)	....	(1.20)
5	0	31.0	58.0	60.0	(2.00)	(1.61)	....	....
6	R	31.8	64.5	61.5	(1.91)	(1.65)	....	....
7	RL	34.2	71.7	66.8	(1.79)	(1.88)	(1.57)	(.52)
8	RLP	37.9	74.1	68.3	(2.08)	(2.03)	(1.66)	(.80)
9	RLPK	37.8	75.4	70.7	(1.73)	(2.09)	(1.99)	(.57)
10	0	30.2	56.3	58.8	(2.38)	(1.62)	....	....
	Crop Increases							
	M over 0	5.2	13.9	7.1	(.53)	(.03)	....	....
	R over 0	.8	6.5	1.5	–(.09)	(.04)	....	....
	ML over M	.4	3.6	2.8	(.38)	–(.03)	....	(1.12)
	RL over R	2.4	7.2	5.3	–(.12)	(.23)	(1.57)	(.52)
	MLP over ML	1.7	1.2	1.0	–(.07)	(.01)	....	(.08)
	RLP over RL	3.7	2.4	1.5	(.29)	(.15)	(.09)	(.28)
	RLPK over RLP	– .1	1.3	2.4	–(.35)	(.06)	(.33)	–(.23)

[1]Soybeans all evaluated as hay, altho some plots were harvested as seed.
[2]Two crops hubam on Plots 3 and 4 but only 1 crop on 7, 8 and 9.

dues alone have been beneficial for the second year corn but have shown little effect on the other crops of the rotation.

Where limestone has been applied, there is usually some increase in average yields, sufficient, at least, to cover the cost of the limestone.

The addition of rock phosphate to the treatment has had very little effect in the manure system. Somewhat more favorable are the results in the residues system, but under present market conditions, the cost of rock phosphate applied in the manner of these experiments exceeds the value of the crop increase. However, the economic story has not all been told, for the application of lime and phosphate has been discontinued in order to observe the residual effects. The results of the next few years, therefore, will be awaited with great interest.

For the effect of potassium treatment Plots 8 and 9 should be compared. No significant response appears from this treatment so far as these common field crops show.

Special Phosphate Experiments

The so-called minor system of plots on the Aledo field is given over to a comparison of the effectiveness of different carriers of phosphorus.

In this experiment each series contains four plots. Plot 1 receives residues treatment only; Plot 2 receives residues and phosphorus in one of the forms under test; Plot 3 receives residues, limestone, and phosphorus; and Plot 4 is similar to Plot 3 with phosphorus omitted. On one series steamed bone meal is used as the carrier of phosphorus and is applied at the rate of 200 pounds per acre per year. On another series superphosphate is applied at the yearly rate of 333⅓ pounds per acre. On a third series rock phosphate serves as the source of phosphorus and is applied at the rate of 666⅔ pounds per acre per year. On the last series basic slag phosphate is applied at the rate of 250 pounds per acre per year.

The yields for all crops harvested on these plots are recorded in Table 8. Table 9, which is derived from Table 8, shows the value of the increase in crop yield presumed to have resulted from applying the various forms of phosphatic fertilizers for the 13 crops harvested since the beginning of the applications up to 1928. In computing these comparisons, each phosphate plot is compared with its neighboring non-phosphate plot. Aside from the soybeans, the figures show without exception more or less crop increase on the phosphorus plots, no matter what the form of carrier employed.

The difficulty in arriving at a general conclusion regarding the comparative economy in the use of these different phosphorus materials is obvious, for all depends upon their relative cost, which fluctuates from time to time. Furthermore, the prices received from farm produce likewise fluctuate; and to complicate matters still further, these fluctuations do not necessarily run parallel with those of the fertilizer cost. However, one may compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions. For the purpose of furnishing an illustration of such a computation, the December 1 market quotations for the years in which the

TABLE 8.—ALEDO FIELD: PHOSPHATE EXPERIMENT

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1916[1] Corn	1917[1] Oats	1918[1] Soybeans	1919 Wheat	1920 Corn	1921 Oats	1922 Clover hay	1923 Corn	1924 Corn	1925 Oats	1926 Wheat	1927 Corn	1928 Corn
501	R..........	53.4	85.5	18.9	32.4	72.8	48.9	(2.88)	83.5	58.2	63.9	44.0	33.9	69.8
502	RbP.......	61.7	91.7	19.0	34.7	86.4	61.9	(3.25)	82.7	66.0	75.0	59.2	63.2	71.7
503	RLbP......	61.5	90.6	23.2	35.6	87.3	53.3	(3.48)	82.5	66.8	73.4	62.0	71.3	78.3
504	RL........	55.1	80.5	22.6	32.9	77.7	47.7	(2.61)	88.2	60.3	64.5	44.6	58.5	72.0
601	R..........	55.2	84.7	19.5	33.0	71.2	53.6	(3.17)	84.7	57.3	64.4	43.3	37.2	71.3
602	RsP........	57.8	87.7	18.7	38.3	87.1	60.9	(3.23)	82.5	65.9	76.1	60.6	54.8	73.2
603	RLsP......	64.7	83.4	23.1	38.2	88.1	52.3	(3.53)	77.6	64.7	78.1	64.4	67.0	74.9
604	RL........	51.9	81.7	24.6	32.8	84.9	50.2	(3.06)	84.1	51.9	64.1	47.3	60.8	74.4
701	R..........	54.3	83.1	20.8	34.2	75.6	52.8	(3.41)	82.8	61.2	66.6	44.8	39.9	72.3
702	RrP.......	58.8	83.3	23.3	36.7	80.4	63.0	(3.60)	87.8	69.3	70.3	59.2	61.8	74.3
703	RLrP......	57.2	81.2	28.1	36.7	80.2	53.3	(3.82)	86.6	70.8	67.8	57.5	67.8	76.5
704	RL........	52.1	81.7	26.9	34.1	82.0	48.9	(3.15)	84.6	62.5	66.3	48.8	63.0	74.6
801	R..........	57.6	73.8	18.0	33.7	68.1	54.8	(2.62)	74.3	58.8	45.0	45.8	42.2	70.4
802	RslP.......	56.4	87.8	20.6	38.1	81.0	66.2	(3.66)	80.0	69.1	66.3	60.2	60.7	69.3
803	RLslP	53.3	78.9	23.7	38.4	83.6	57.0	(3.63)	82.0	70.2	66.7	66.0	73.1	71.0
804	RL........	51.8	77.5	21.8	33.3	70.4	59.8	(2.99)	82.6	59.9	53.9	48.2	60.4	75.1

[1]No residues.

respective crops were actually produced have been applied to the results of these Aledo plots. The value of soybeans is arbitrarily set at $1.50 a bushel. For the cost of fertilizer materials the prices of phosphates are estimated as follows: bone meal, $40 a ton; superphosphate, $24; rock phosphate, $12; and slag phosphate, $20 a ton.

TABLE 9.—ALEDO FIELD: PHOSPHATE EXPERIMENTS

Value of Crop Increases Produced by the Various Forms of Phosphate, Computed from Yields in Table 8

Comparison of treatments	Wheat *2 crops*	Corn *6 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans *1 crop*	Total increase *13 crops*	Cost of phosphate *13 years*	Profit from *13 crops*	Profit per acre per year
Bone meal, residues, *over* residues....................	$23.35	$44.04	$11.67	$ 4.63	$ .15	$83.83	$52.00	$31.83	$ 2.45
Bone meal, residues, lime *over* residues, lime........	26.90	27.01	11.31	10.88	.90	77.00	52.00	25.00	1.92
Superphosphate, residues, *over* residues............	32.23	32.12	8.15	.75	−1.20	72.05	52.00	20.05	1.54
Superphosphate, residues, lime, *over* residues, lime ...	32.20	25.33	6.62	5.88	−2.25	67.77	52.00	15.77	1.21
Rock phosphate, residues, *over* residues............	22.81	34.51	4.38	2.38	3.75	67.83	52.00	15.83	1.22
Rock phosphate, residues, lime, *over* residues, lime ...	16.07	17.15	1.49	8.38	1.80	44.89	52.00	− 7.11	− .55
Slag phosphate, residues, *over* residues............	26.80	32.46	19.86	13.00	3.90	96.02	32.50	63.52	4.89
Slag phosphate, residues, lime, *over* residues, lime ...	32.43	24.59	11.07	8.00	2.85	78.94	32.50	46.44	3.57

Reckoned on the basis of the above prices, it appears from the last column of Table 9 that slag phosphate has produced the most profitable returns of the four phosphorus carriers in the test, bringing an average profit of $4.89 an acre yearly where applied without limestone and $3.57 where applied with limestone. Bone meal has given an average profit of $2.45 applied without limestone and $1.92 applied with limestone. Superphosphate has returned $1.54 used without limestone and $1.21 used with limestone. Rock phosphate has produced a profit of $1.22 an acre a year when applied without limestone and a loss of 55 cents when used with limestone.

In considering these results, it may be pointed out that the quantities of phosphatic materials employed in these experiments are, with the possible exception of the slag phosphate, greater than ordinarily would be used, or need to be used, in good farm practice. Moreover, no consideration is given in these comparisons to the relative phosphorus reserves which should have accumulated in the soil. Finally, it should be emphasized that the order of these values might be easily shifted by a relatively small change in commodity prices.

Limestone at the rate of 4 tons an acre was applied to Plots 3 and 4 in 1912 when the land was still under alfalfa, and another dressing was added in 1917 after the present experiments were under way. The results from the limestone treatment are shown in Table 10.

At the prices for produce and limestone assumed in these computations, a profit of $1.69 an acre a year for limestone applied without phosphate of any kind is found. Where limestone was applied with bone meal, the limestone profit was 99 cents an acre a year, and with superphosphate it was likewise 99 cents an acre. Used with rock phosphate, the crop increases were so small that there

TABLE 10.—ALEDO FIELD: PHOSPHATE EXPERIMENTS
Value of Crop Increases Produced by Limestone, Computed from Yields in Table 8

Comparison of treatments	Wheat *2 crops*	Corn *6 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans *1 crop*	Total increase *13 crops*	Cost of limestone[1] *13 years*	Profit from *13 crops*	Profit per acre per year
Limestone, residues, *over* residues	$ 3.25	$22.14	$−.40	$−.84	$ 7.01	$31.16	$ 9.18	$21.98	$ 1.69
Limestone, residues, bone meal, *over* residues, bone meal	5.31	11.35	−3.76	2.88	6.30	22.08	9.18	12.90	.99
Limestone, residues, superphosphate, *over* residues, superphosphate	4.43	11.93	−4.58	3.75	6.60	22.02	9.18	12.84	.99
Limestone, residues, rock phosphate, *over* residues, rock phosphate	−2.07	5.00	−5.04	2.75	7.20	7.84	9.18	−1.34	− .10
Limestone, residues, slag phosphate, *over* residues, slag phosphate	7.71	11.26	−1.81	− .38	4.65	21.44	9.18	12.26	.94

[1]Owing to the fact that the first application of limestone on these plots was made for alfalfa four years before the present experiments were started, the total expense of $12 an acre for limestone is prorated, leaving a charge of $9.18 for the 13 crops involved in the present experiments.

was a loss of 10 cents an acre a year. Applied with slag phosphate, the returns show a profit of 94 cents an acre a year.

It appears, therefore, that by distributing the cost of the limestone over the years since its first application, this material has returned a moderate profit except where used with rock phosphate.

It should be observed that the Aledo field represents one of those borderline cases, so to speak, in which the upper soil is nearly neutral or only slightly acid and the lime requirement, therefore is not very marked. As time goes on, however, and cropping continues, a greater need for lime will probably develop. By discontinuing liming on these plots the annual cost of the limestone already applied is automatically reduced, so that net returns which hitherto have perhaps represented an actual loss may sooner or later result in a positive profit.

THE MORROW PLOTS

As representing the soil type Brown Silt Loam, the field experiments on the Morrow Plots, which have been continued for more than half a century, will be of special interest.

The Morrow Plots are located on the campus of the University of Illinois. This series now consists of three plots divided into halves, and the halves are subdivided into quarters. On one plot, corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. In 1925 the phosphates were evened up to a total of 3,300 pounds of bone meal and 13,200 pounds of rock phosphate and their application discontinued. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre. From 1903 until 1920, legumes were seeded in the corn on the south half of each plot. Legumes, chiefly red clover until 1918 and sweet clover since that time, have been seeded in the oats on the south half of Plot 4.

Summarizing the data from these Morrow plots into two periods, with the second period beginning in 1904, when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the untreated, continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oat production. The averages for the three-year system on the untreated land show a slight increase in corn yield, a small decrease in oats, and a considerable reduction in clover.

Crop rotation has noticeably improved the yields over continuous corn growing. The three-year rotation has been more effective than the two-year rotation in maintaining yields over the entire period. The two-year rotation, however, has

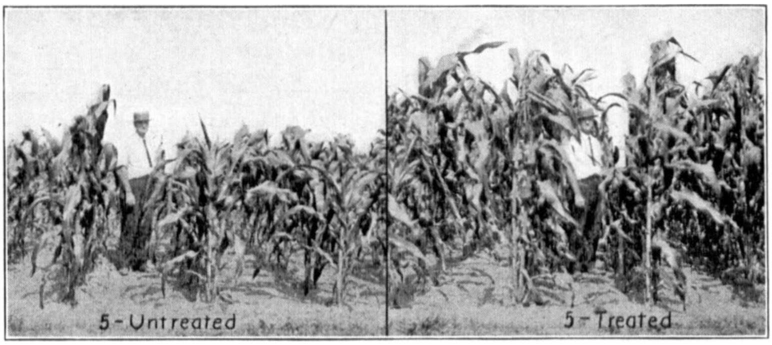

FIG. 8.—CORN ON THE MORROW PLOTS IN THE THREE-YEAR ROTATION

Both of these plots are under a good crop rotation of corn, oats, and clover. No soil treatment is applied to the plot at the left, while that at the right receives manure, limestone, and phosphate. The one is yielding at the rate of 50 bushels an acre, the other at 67 bushels.

been gaining on the three-year rotation in recent years probably because of the influence of sweet clover.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

Thruout the season the crops growing on the treated soil are usually at a more advanced stage of development than those growing on the untreated soil. In corn this shows up at husking time in drier, sounder ears than those found on the untreated land.

An important principle of soil management is demonstrated in these experiments; namely, that the best results are not obtained thru crop rotation alone nor thru soil fertilization alone, but it is the combination of these two practices that brings out the highest possibilities for production.

The practices in rotation and soil treatment which have been the most effective in increasing the crop-producing capacity of the soil have also been the most profitable financially. These better practices not only have increased the yields but they have made possible a greater economy in production, an important factor in increasing farm profits.

TABLE 11.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY

Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover[1]
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		25 crops	*12 crops*	*13 crops*	*9 crops*	*8 crops*	*8 crops*
1904 to 1928	None........	25.0	35.1	34.0	49.3	45.1	(1.49)
	MLP........	40.2	60.6	59.2	67.2	62.7	(2.83)

[1]Including all legume crops evaluated as clover hay.

For further information concerning these long-time soil experiments, the reader is referred to Bulletin 300, "Lessons from the Morrow Plots," where these investigations are described and discussed in detail.

THE KEWANEE FIELD

The Kewanee experiment field, representing the soil type Brown Silt Loam, is located in Henry county about midway between Kewanee and Galva. This field has been in operation since 1915. It includes 20 acres of the dark-colored loessial soil characteristic of the region. Altho the main soil type represented is Brown Silt Loam, a detailed examination reveals the presence of a second type occupying the basin of the draw which traverses the field in a winding direction. This minor type is classified as Black Clay Loam On Drab Clay. The topography of the land is rather rolling and it has a tendency to wash at certain spots. The field is laid out in two systems of plots designated as the major and the minor series.

The Major Series

A rotation system of wheat, corn, oats, and clover has been practiced on the major series, the crops being managed mainly as described on page 42. Since 1921 the clover on the residues plots has been harvested for hay instead of seed and the oat straw has not been returned to the land. Since 1922 the periodic application of limestone has been suspended after the different series had received an average total of 6¾ tons to the acre, and no more is to be applied until it shall be needed again. The practice of returning the wheat straw has been discontinued since 1922, and since 1925 only one crop of clover hay on the residues plots has been removed, the second crop being plowed down as green manure. The phosphate applications were suspended in 1927 after evening up all phosphate plots to a total of 4 tons per acre.

Table 12 gives a summary of the results showing the average annual yields for the different kinds of crops, including the years since the complete soil treatments have been in effect.

In looking over these results one may observe first the effect of animal manure, which has given profitable increases in all the crops. Residues alone show no significant effect.

Limestone in addition to manure has resulted in a small improvement, probably sufficient to cover the cost. It has been somewhat more effective in the grain system than in the livestock system.

Phosphorus, as usual, shows up in these averages to best advantage on the wheat crop in the residues system. Where used with manure and limestone, little effect was produced except on the wheat; but where used with residues and limestone, fair increases were produced in all crops, sufficient to return a financial profit under present market conditions. A study of the detailed data reveals a fact of interest in this connection which these averages do not bring out, and that is that the phosphate exerted very little influence during the earlier years of the experiments. Within the past seven or eight years, however, the

TABLE 12.—KEWANEE FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1917-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *10 crops*	Corn *12 crops*	Oats *12 crops*	Clover[1] *11 crops*
1	0	29.0	54.6	59.0	(1.64)
2	M	32.4	66.0	71.0	(2.23)
3	ML	35.2	70.6	73.2	(2.30)
4	MLP	40.0	72.1	72.4	(2.48)
5	0	30.3	56.1	60.6	(1.56)
6	R	31.6	58.2	59.6	(1.46)
7	RL	34.2	66.5	63.3	(1.71)
8	RLP	39.8	70.9	69.0	(1.89)
9	RLPK	40.6	74.4	70.6	(1.97)
10	0	28.1	50.3	56.4	(1.29)
	Crop Increases				
	M over 0	3.4	11.4	12.0	(.59)
	R over 0	1.3	2.1	− 1.0	−(.10)
	ML over M	2.8	4.6	2.2	(.07)
	RL over R	2.6	8.3	3.7	(.25)
	MLP over ML	4.8	1.5	− .8	(.18)
	RLP over RL	5.6	4.4	5.7	(.18)
	RLPK over RLP	.8	3.5	1.6	(.08)

[1]Including some seed evaluated as hay.

phosphorus treatment has come suddenly into evidence and the trend of its effectiveness seems at present to be on the upgrade.

No significant response appears as the result of potassium fertilization, thus indicating the futility of purchasing potassium fertilizer for use in this kind of a cropping system on this kind of soil.

Comparative Phosphate Experiments

Four short series having only 4 plots each constitute the so-called minor system on the Kewanee field. These plots are now given over to a comparison of the effectiveness of rock phosphate and superphosphate.

Alfalfa was grown on these plots until 1922. In the beginning, limestone was applied to Plots 3 and 4 at the rate of 4 tons an acre. This application was repeated in 1919. In 1922 the present experiments with phosphates were begun and the same rotation practiced on the larger series described above was established on these series. In this comparison rock phosphate is used on Plots 1 and 3 at the annual rate of 400 pounds an acre, applied once in the rotation ahead of the wheat, but beginning with 1927 rock phosphate will be applied at the same time as the superphosphate. Superphosphate is used on Plots 2 and 4 at the annual rate of 200 pounds an acre. It is applied twice in the rotation, one-half for wheat and one-half for oats. A summary of the annual crop yields and corresponding money values is given in Table 13.

In comparing these two forms of phosphate the following set of prices are assumed as representing the average market conditions for the past seven years

TABLE 13.—KEWANEE FIELD: PHOSPHATE EXPERIMENT

Average Annual Crop Yields and Corresponding Money Values 1922-1928
Bushels or (tons) per acre

Soil treatment applied	Wheat *7 crops*	Corn *7 crops*	Oats *7 crops*	Legume hay *7 crops*	Value per acre
Residues, rock phosphate..........	43.3	74.1	76.5	3.09	$43.89
Residues, superphosphate..........	45.1	73.0	78.2	3.02	44.17
Residues, limestone, rock phosphate	38.8	73.0	73.5	3.09	42.05
Residues, limestone, superphosphate	46.6	75.1	77.0	3.01	44.83

(December 1 quotations): wheat, $1.21 a bushel; corn, 68 cents; oats, 39 cents; and hay, $13.90 a ton. For the cost of the two phosphorus carriers, an estimate of $12 a ton for rock phosphate and $24 a ton for superphosphate may be taken, thus making the expense for the two kinds of phosphate equal.

With these prices applied to the yields given in Table 13, it is found that without limestone there is very little difference in value of crops produced under the two forms of phosphate. The 38 cents in favor of the superphosphate is scarcely significant in view of the experimental errors involved in this sort of test. In the presence of limestone the difference in crop values is $2.78 per acre per year in favor of superphosphate. Wheat has been the crop most affected by the form of phosphate applied.

It is to be borne in mind that the order of values can easily be shifted by a change in the relative yields of the respective crops or by a change in commodity prices. Furthermore no consideration has been given here to any possible difference in the residual effects of the two forms of phosphate which might appear upon discontinuing the treatments.

THE BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and, since 1905, they have been grown in the sequence named.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. For 20 years all of the phosphorus on this field was applied in the form of steamed bone meal at the rate of 200 pounds an acre a year.

Table 14 presents a summary of the work to 1923 by average annual yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they were applied.

The value of limestone on this field is difficult to assess on account of the erratic results found upon comparing Plots 1 and 2. Here both corn and wheat appear to have suffered from the application of limestone, but the difficulty may well be attributable to soil variability. Comparing Plots 9 and 10, it would

TABLE 14.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
1	0	44.6	40.6	26.5	(.74)
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.90)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
10	RbPK	58.8	52.8	49.3	(.83)
	Crop Increases				
	For limestone				
	L over 0	− 3.5	4.1	− 2.4	(.06)
	LRbPK over RbPK	5.4	10.3	1.1	−(.02)
	For residues				
	LR over L	6.0	1.5	3.8	(.08)
	LRbP over LbP	4.8	11.7	4.0	−(1.35)
	LRK over LK	2.4	3.3	2.0	−(.08)
	LRbPK over LbPK	3.3	5.9	5.9	−(1.63)
	For phosphorus				
	LbP over L	14.3	9.6	21.6	(1.74)
	LRbP over LR	13.1	19.8	21.8	(.31)
	LbPK over LK	14.7	13.7	19.0	(1.54)
	LRbPK over LRK	15.6	16.3	22.9	−(.01)
	For potassium				
	LK over L	4.7	− 1.2	1.4	(.10)
	LRK over LR	1.1	.6	− .4	−(.06)
	LbPK over LbP	5.1	2.9	− 1.2	−(.10)
	LRbPK over LRbP	3.6	− 2.9	.7	−(.38)

[1]Two crops of seed on Plots 3, 6, 7, and 9 evaluated as hay.

appear that in combination with residues, phosphorus, and potassium, the limestone on the whole was beneficial.

The residues treatment, supplying organic matter and nitrogen, shows a beneficial effect on the grain crops, but not on the clover.

The prominent feature of the results on the Bloomington field is the effect of phosphorus. In all of the grain crops on every plot where bone meal was applied, there was a remarkable response to the treatment, as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues, with limestone, residues, and phosphorus) we find that the phosphorus treatment produced an average annual increase in the yield of corn of about 13 bushels an acre, while the yield of oats was increased by about 20 bushels, and that of wheat by about 22 bushels. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8, where potassium instead of residues was present.

Quite different are the results from the use of potassium on this field. The potassium was applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There was a moderate increase in the corn yield where potassium was used and particularly where residues were absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is the outstanding limiting factor in production and the application of this element in the form of steamed bone meal is attended by a high financial profit.

New Phosphate Experiments

In view of this remarkable response to bone meal on the Bloomington field, it was of interest to know how other carriers of phosphorus would behave, and accordingly some experiments were planned to investigate this question. For this purpose, the plots were divided in 1924 and certain new treatments were applied in order to compare the effects of rock phosphate and of superphosphate with bone meal, and at the same time to determine the residual effect of the accumulated phosphorus resulting from the continuous application of the bone meal in presumably somewhat excessive amounts.

The following modifications of the original plots were introduced:

An extra plot, No. 11, was added to the series and all plots were divided into north and south halves. Residues including cornstalks, the second crop of red clover, and other leguminous green manure crops are plowed down on all plots except Plot 1-S. Different phosphorus carriers are applied at the following acre rates per rotation: bone meal, 1000 pounds, to Plots 2-N, 4-N, 6-N, 8-N, 9-N, and 10-N; rock phosphate, 2500 pounds, to Plots 3-N, 5-N, 7-N, and 11-N; superphosphate, 1000 pounds, to Plots 3-S, 5-S, 7-S, and 11-S. Two-fifths of the rotation application of these phosphates are made preceding the oats crop, two-fifths ahead of the wheat crop, and one-fifth in preparation for the corn crop.

Table 15 indicates the arrangement of these modified plots and also gives the results of the five years in which these later experiments have been in progress.

In arriving at the financial results presented in the table, the values of the crops are based upon December 1 farm price quotations for the years in which the respective crops were produced. In deducting the annual cost for the different treatments, the total amounts of materials applied during the entire period of operation on the field were prorated. The expense for limestone is reckoned here at $3 a ton, rock phosphate at $14, superphosphate at $28, bone meal at $48, and residues at 75 cents an acre.

It should be mentioned in considering the results that the soil of these plots is rather variable, with little provision for duplication; and also that some of the treatments are not now strictly comparable with one another on account of the previous history of the plots. Nevertheless, making allowances for these facts, certain figures in the last column of the table showing the net average acre value per year indicate effects worthy of consideration.

TABLE 15.—BLOOMINGTON FIELD: NEW PHOSPHATE EXPERIMENTS
Crop Yields and Values 1924-1928—Bushels or (tons) and dollars per acre

Plot No.	Soil treatment applied: Previous	Soil treatment applied: Present	1924 Oats	1925 Clover	1926 Wheat	1927 Corn	1928 Corn	Average annual acre values: Gross	Cost of treatment	Net
1-N	0	R	60.6	(.79)	29.3	49.8	49.0	$29.29	$ .75	$28.54
1-S	0	0	58.4	(2.54)	19.5	41.0	33.4	28.82	......	28.82
2-N	L	RLP (bone)	72.6	(1.63)	35.0	58.6	52.2	36.18	6.55	29.63
2-S	L	RL	53.2	(.75)	18.7	46.0	35.2	23.41	1.75	21.66
3-N	RL	RLP (rock)	68.2	(2.18)	32.5	63.6	64.6	39.35	5.25	34.10
3-S	RL	RLP (super)	71.3	(1.74)	41.0	67.6	59.6	40.18	4.55	35.63
4-N	LP (bone)	RLP (bone)[1]	57.6	(1.81)	37.3	60.0	49.6	35.79	6.55	29.24
4-S	LP (bone)	RLP (bone)[2]	67.2	(1.89)	36.7	63.6	60.0	38.71	5.30	33.41
5-N	LK	RLKP (rock)	63.2	(1.66)	32.5	61.4	56.2	35.73	7.65	28.08
5-S	LK	RLKP (super)	78.4	(1.59)	40.7	69.4	55.6	39.99	6.95	33.04
6-N	RLP (bone)	RLP (bone)[1]	68.8	(2.18)	40.5	60.8	55.8	39.73	6.55	33.18
6-S	RLP (bone)	RLP (bone)[2]	71.6	(2.21)	40.0	64.2	60.4	41.09	5.30	35.79
7-N	RLK	RLKP (rock)	71.2	(2.11)	35.3	66.4	58.4	39.62	7.65	31.97
7-S	RLK	RLKP (super)	80.9	(1.66)	40.7	74.8	62.8	42.23	6.95	35.28
8-N	LKP (bone)	RLKP (bone)[1]	60.9	(1.69)	39.2	67.4	56.2	38.10	8.95	29.15
8-S	LKP (bone)	RLKP (bone)[2]	65.0	(1.59)	36.0	69.4	63.0	38.62	7.70	30.92
9-N	RLKP (bone)	RLKP (bone)[1]	60.9	(2.18)	43.8	75.8	60.4	42.56	8.95	33.61
9-S	RLKP (bone)	RLKP (bone)[2]	72.2	(1.65)	41.5	77.8	62.6	41.97	7.70	34.27
10-N	RKP (bone)	RKP (bone)[1]	48.2	(1.93)	45.7	56.6	51.2	37.02	7.95	29.07
10-S	RKP (bone)	RKP (bone)[2]	51.2	(1.53)	43.0	60.6	58.0	36.89	6.70	29.99
11-N	[3]	RP (rock)	70.4	(1.68)	45.3	61.8	47.4	38.43	4.25	34.18
11-S	[3]	RP (super)	60.0	(1.78)	44.5	63.0	57.2	39.11	3.55	35.56

[1]Bone meal applications omitted from 1917 to 1924. [2]No bone meal applied since 1917. [3]New plot added in 1924.

In answering the question as to whether other carriers of phosphorus would be as effective as the bone meal in building up this soil, attention is called to the results on Plots 2-N, 3-N, and 3-S where bone meal, rock phosphate, and superphosphate respectively have been employed in addition to limestone and residues. Unfortunately the comparison here is not altogether perfect in that the residues treatment on Plot 2-N was not introduced until 1924, whereas the other two plots had been under residues in the old system before the present experiments were begun and may, therefore, have an advantage in this respect over the bone meal plot. However this may be, the results as they stand at present place both rock phosphate and superphosphate ahead of bone meal.

Between rock phosphate and superphosphate four direct comparisons in different combinations with other materials are afforded (Plots 3, 5, 7, and 11.) In some years on some lots the results are in favor of superphosphate; in other years on the same plots the reverse is true. As the results stand at present, the majority are in favor of superphosphate but their inconsistency makes it difficult to come to any final conclusion. It may be noted that in these comparisons the two materials are not applied in amounts proportionate to equal cost as in other

cases reported. Here 200 pounds per acre per year of superphosphate figured at $2.80 are applied against 500 pounds of rock phosphate valued at $3.50 per acre per year.

For light on the question of residual effect of accumulated phosphorus in the soil, attention is called to the results on Plots 4, 6, 8, 9, and 10, where the north half-plots are now regularly receiving bone meal, while the south halves have received none since 1917. Invariably the net return is higher on the south half, thus indicating that the reserve phosphate accumulated in the soil from previous applications is still exerting a beneficial effect that is more than adequate to offset the expense involved in renewed applications.

By way of a summary of the main lessons brought out at this time by the Bloomington experiments, the following statements may be made.

The results indicate an outstanding phosphorus hunger.

This phosphorus need is satisfied by the application of either bone meal, rock phosphate, or superphosphate.

There is a pronounced residual effect from previous excessive applications of phosphorus carried in the form of bone meal.

THE MINONK FIELD

A University experiment field representing the soil type Black Clay Loam On Drab Clay is located in Woodford county near Minonk. This field was established in 1910. It comprizes 15 acres of dark-colored prairie soil of loessial and drift origin. The experiment plots lie mainly on Black Clay Loam On Drab Clay, altho a detailed examination reveals the presence of three other soil types distinguishable on account of certain profile characteristics. These are Brown Silt Loam, Brown Silt Loam On Calcareous Drift, and Brown Silt Loam On Calcareous Clay.

The field is laid out into four series of 10 plots each. The plots are one-fifth acre in size except in Series 100, where they are one-tenth acre. A crop rotation of corn, oats, clover, and wheat was practiced until 1923, when it was changed to corn, corn, oats, and wheat, with a seeding of hubam clover in the oats on all plots and biennial sweet clover in the wheat on the residues plots. In 1921 the practice of returning the oat straw on the residues plots was discontinued, and in 1922 the return of the wheat straw was likewise discontinued. Up to that time limestone, varying in total quantity from 7½ to 9 tons an acre on the different series, had been applied. These applications were then suspended until such time as the need for more lime becomes apparent. The applications of rock phosphate were likewise indefinitely suspended in 1923 after evening up the total applications to 4 tons an acre on all the phosphate plots.

The average annual yields of all crops produced since the complete soil treatments have been in effect are given in Table 16.

In looking over these results, one observes from the good yields on the untreated plots the naturally high productiveness of this land. There is more or less response to farm manure; in the corn the yield is markedly increased by its use. Residues alone have likewise increased the yields of the grain crops. Limestone seems to have had no material effect on crop yields. Evidently this

TABLE 16.—MINONK FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1912-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover[1]	Soybeans	Stubble clover	
							Hubam	Sweet clover
		14 crops	*23 crops*	*16 crops*	*5 crops*	*4 crops*	*2 crops*	*2 crops*
1	0..........................	30.1	50.2	58.8	(2.58)	19.3	(.72)	......
2	M..........................	33.8	60.6	61.3	(2.81)	20.5	(.94)	......
3	ML.........................	32.4	61.0	60.3	(2.74)	21.7	(.83)	......
4	MLP........................	34.4	61.0	59.2	(2.93)	21.0	(.97)	......
5	0..........................	31.4	48.6	55.5	(1.36)	20.7	(.86)	......
6	R..........................	33.8	59.3	61.7	(1.50)	20.6	(.91)	(1.19)
7	RL.........................	30.8	61.1	61.6	(1.51)	19.3	(.90)	(1.16)
8	RLP........................	32.7	62.3	63.0	(1.47)	19.7	(1.06)	(1.33)
9	RLPK.......................	32.0	59.9	63.2	(1.49)	17.2	(1.20)	(1.50)
10	0..........................	26.1	44.0	55.2	(2.30)	15.3	(.58)	......
	Crop Increases							
	M over 0................	3.7	10.4	2.5	(.23)	1.2	(.22)	......
	R over 0................	2.4	10.7	6.2	(.14)	− .1	(.05)	(1.19)
	ML over M...............	− 1.2	.4	− 1.0	−(.07)	1.2	−(.11)	......
	RL over R...............	− 3.0	1.8	− .1	(.01)	− 1.3	−(.01)	−(.03)
	MLP over ML..............	2.0	0.0	− 1.1	(.19)	− .7	(.14)	......
	RLP over RL..............	1.9	1.2	1.4	−(.04)	.4	(.16)	(.17)
	RLPK over RLP...........	− .7	− 2.4	.2	(.02)	− 2.5	(.14)	(.17)

[1]Including some seed evaluated as hay.

soil does not need lime. The use of rock phosphate has not been profitable either in the manure or the residues system. Potassium, as used in these experiments, has likewise been ineffective.

These results therefore indicate the advisability of furnishing plenty of organic matter, either thru stable manure or thru crop residues, including leguminous green manure, as the best practical means, for the present, of improving the productiveness of this naturally fertile soil. As time goes on, with changing soil conditions and shifting market values, the situation may develop under which a different recommendation will be warranted.

THE HARTSBURG FIELD

Black Clay Loam as noted on page 17, occupies about 87 square miles in Coles county. The results of the Hartsburg field, situated in Logan county just east of the town of Hartsburg, are suggestive of the treatments that are effective on this type of soil.

The Hartsburg field was started in 1911. It is laid off in five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series.

The crops were handled mainly as described on page 42 until 1918 when it was planned to remove one hay crop and one seed crop of clover from the residues

TABLE 17.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1913-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Barley	Corn	Oats	Clover	Soybeans	Alfalfa	Stubble clover	
									Hubam	Sweet-clover
		13 crops	*1 crop*	*24 crops*	*17 crops*	*7 crops*	*2 crops*	*8 crops*	*1 crop*	*1 crop*
1	0	24.9	35.4	48.1	48.1	(1.84)	(1.29)	(3.47)	(.83)	....
2	M	29.2	44.2	58.8	52.9	(2.16)	(1.64)	(3.67)	(1.15)	....
3	ML	34.0	50.0	64.5	58.3	(2.32)	(1.82)	(3.91)	(.91)	....
4	MLP	36.2	50.0	63.8	57.8	(2.39)	(1.92)	(4.19)	(1.17)	....
5	0	29.7	42.7	53.3	47.0	(1.28)	25.8	(3.33)	(.71)	....
6	R	32.7	47.5	63.7	53.3	(1.67)	26.8	(3.78)	(.75)	(.85)
7	RL	30.1	53.3	66.9	51.3	(1.64)	28.4	(3.45)	(.68)	(.75)
8	RLP	34.3	46.9	67.3	55.4	(1.79)	26.1	(4.04)	(.72)	(.90)
9	RLPK	33.4	55.6	65.4	54.5	(1.70)	26.4	(4.16)	(.80)	(1.00)
10	0	30.5	45.8	52.8	48.0	(2.02)	(1.69)	(3.20)	(.75)	....
	Crop Increases									
	M over 0	4.3	8.8	10.7	4.8	(.32)	(.35)	(.20)	(.32)	....
	R over 0	3.0	4.8	10.4	6.3	(.39)	1.0	(.45)	(.04)	(.85)
	ML over M	4.8	5.8	5.7	5.4	(.16)	(.18)	(.24)	−(.24)	....
	RL over R	− 2.6	5.8	3.2	− 2.0	−(.03)	1.6	−(.33)	−(.07)	−(.10)
	MLP over ML	2.2	0.0	− .7	− .5	(.07)	(.10)	(.28)	(.26)	....
	RLP over RL	4.2	− 6.4	.4	4.1	(.15)	− 2.3	(.59)	(.04)	(.15)
	RLPK over RLP	− .9	8.7	− 1.9	− .9	−(.09)	.3	(.12)	(.08)	(.10)

plots. In 1921 it was decided to harvest all the clover as hay. At that time the return of the oat straw to the land was discontinued. In 1922 the return of the wheat straw was likewise discontinued. The application of limestone was discontinued in 1922 after amounts ranging from 7½ to 10 tons an acre on the different series had been applied, and no more will be added until further need for it becomes apparent. In 1923 the phosphate applications were evened up to a total of 4 tons an acre on all phosphate plots, and no more will be applied for an indefinite period. At that time the rotation on the first four series was changed to corn, corn, oats, and wheat with a seeding of hubam clover in the oats on all plots, and a seeding of biennial sweet clover in the wheat on the residues plots. The rotation was changed also on the fifth series to corn, oats, wheat, and a mixture of alfalfa with red clover. The soil treatments are as indicated in Table 17, which summarizes by crops the yields for the period during which the plots have been under full treatment.

The outstanding feature of the results on the Hartsburg field is the large increases produced by organic manure whether in the form of crop residues or stable manure. The behavior of limestone is rather perculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure it shows some increase in practically all crops, while with residues its effect on several of the crops appears negative.

Altho rock phosphate has given some increases in wheat yield in both the manure and the residues systems, the results with other crops have been such

as to render the use of this material unprofitable on this field. The addition of potassium appears to have produced no significant effect excepting on the one barley crop.

THE TOLEDO FIELD

As representative of Gray Silt Loam On Tight Clay, the Toledo experiment field, which lies only about eight miles south of Coles county, may be taken. This field of 17 acres was established in 1913. It was laid out into two separate systems of plots, one including four series of ten plots each and the other containing four series of four plots each.

On the larger series the plots have been maintained, for the most part, under the systems of cropping and treatment described on page 42. In 1922 the application of limestone was discontinued. The plots had received a total of 6½ to 8 tons an acre on the different series, and no more will be applied until the need for lime becomes apparent. Two years later the application of rock phosphate was likewise discontinued after a total of 4 tons to the acre had been applied.

Table 18 presents a summary of the crop yields including the years in which the complete plot treatments have been in effect. The results are characteristic of those generally obtained on this gray prairie soil, namely: very poor yields on the untreated land and a very high response to limestone and organic matter.

Manure alone has had relatively little effect and residues alone has had even less.

Limestone has had a very pronounced effect in increasing the yields of all crops.

TABLE 18.—TOLEDO FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1914-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *11 crops*	Corn *15 crops*	Oats *14 crops*	Clover or mixed hay *7 crops*	Soybeans *3 crops*	Sweet clover *3 crops*
1	0	8.8	21.9	15.1	(.10)	(.70)	.11
2	M	10.7	28.6	18.5	(.22)	(.72)	.24
3	ML	22.0	40.7	29.7	(1.18)	(1.27)	2.45
4	MLP	23.4	40.3	30.4	(1.25)	(1.21)	2.42
5	0	7.8	17.6	14.4	(.10)	(.38)	.26
6	R	9.0	19.3	16.2	(.23)	(.47)	.53
7	RL	20.6	28.6	31.1	(1.35)	(.94)	1.84
8	RLP	23.5	29.5	32.3	(1.54)	(1.05)	1.77
9	RLPK	28.1	41.0	35.7	(1.82)	(1.18)	2.48
10	0	6.8	15.4	15.4	(.17)	(.53)	.19
	Crop Increases						
M	over 0	1.9	6.7	3.4	(.12)	(.02)	.13
R	over 0	1.2	1.7	1.8	(.13)	(.09)	.27
ML	over M	11.3	12.1	11.2	(.96)	(.55)	2.21
RL	over R	11.6	9.3	14.9	(1.12)	(.47)	1.31
MLP	over ML	1.4	− .4	.7	(.07)	−(.06)	− .03
RLP	over RL	2.9	.9	1.2	(.19)	(.11)	− .07
RLPK	over RLP	4.6	11.5	3.4	(.28)	(.13)	.71

There has been only a very limited response to rock phosphate—not enough in either the manure or the residues system to pay for the cost of the material.

Potassium has produced a beneficial effect on all crops, becoming very pronounced on the corn. The experiments show only the effect of potassium as used in the combination with residues, limestone, and rock phosphate.

Tillage Experiments

The second set of plots on the Toledo field has been devoted mainly to an investigation in soil tillage, the purpose being to compare the effects of subsoiling, deep tilling, and dynamiting with that of ordinary plowing. A crop rotation of corn, soybeans, wheat, and sweet clover was adopted, second-year sweet-clover stubble being plowed late in the fall for corn. An application of 4 tons of limestone an acre was made on all plots in 1913; 3 tons were applied for the 1917 crop, and 2 tons for the 1921 crop. One ton of rock phosphate was applied in the fall of 1914, and again in the fall of 1918.

A summary of the crop yields is given in Table 19. For a detailed account of these experiments the reader is referred to Bulletin 258 of this Station, "Experiments with Subsoiling, Deep Tilling, and Dynamiting."

TABLE 19.—TOLEDO FIELD: TILLAGE EXPERIMENTS
Average Annual Yields 1913-1922—Bushels per acre

Tillage treatment	Corn *9 crops*	Soybeans *7 crops*	Wheat *6 crops*	Sweet-clover seed *6 crops*
Plowed 7 inches deep	40.2	16.3	13.5	3.68
Subsoil 14 inches deep	41.9	16.2	12.9	3.65
Deep-tilled 14 inches	37.4	15.2	10.8	3.18
Dynamited	40.3	16.4	11.7	4.25

The conclusions reached from the results of these experiments is that none of the special tillage treatments had any beneficial effect on crop yields. Deep tilling apparently decreased yields, probably because of the mixing of subsurface and subsoil with the surface soil.

THE VIENNA FIELD

Coles county, as indicated in the descriptions of certain of its soil types, includes considerable land that is subject to destruction thru erosion or washing. Yellow Silt Loam, which occupies about 29 square miles in the county, is particularly susceptible to this kind of damage. Operators of land in Coles county will therefore be interested in experiments conducted on the Vienna field, in Johnson county, to test out different methods of reclaiming badly gullied land and preventing further erosion.

The Vienna field is representative of the sloping, erodible land so common in the extreme southern part of the state. When the experiments were started the whole field, with the exception of about three acres, had been abandoned because so much of the surface soil had washed away, and there were so many gullies that further cultivation was unprofitable. For the purpose of the experi-

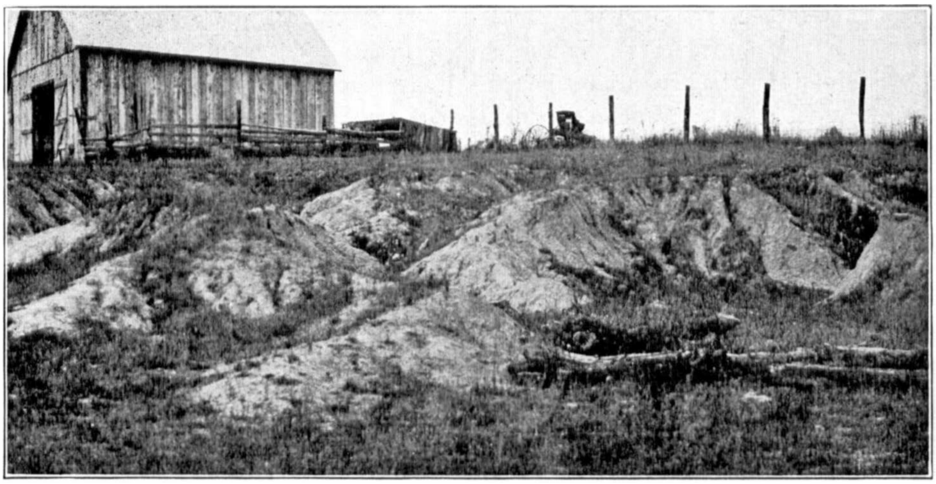

FIG. 9.—PROPER SOIL AND CROPPING METHODS WOULD HAVE PREVENTED THIS CONDITION
This abandoned hillside is just over the fence from the field shown in Fig. 10. Yellow Silt Loam is particularly susceptible to this kind of damage.

ments the field was divided into different sections (see Table 20). These were not entirely uniform; some parts were much more washed than others, and portions of the lower-lying land had been affected by soil material washed down from above. The higher land had a very low producing capacity; on many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except the one designated as D, which included but three plots.

TABLE 20.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

Section A included the steepest part of the field and contained many gullies. The land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

Section B was used to test the so-called embankment method. Ridges were plowed up which were sufficiently high so that when there were heavy falls of rain the water would break over and run in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about 8 loads of manure an acre were turned under each year for the corn crop.

Section D was washed to about the same extent as Section C. It was farmed in the most convenient way, without any special effort to prevent washing.

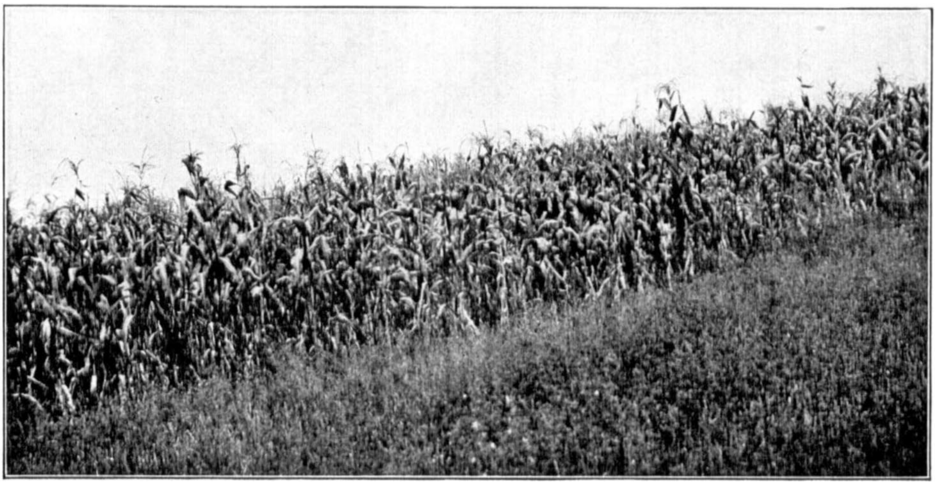

FIG. 10.—CORN GROWING ON AN IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD
This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 9.

Careful records were kept for nine years. The results, summarized in Table 20 indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels on the check series (D). Wheat yielded 11.1 bushels on the protected series, in comparison with 4.6 bushels on the check, and clover yielded $\frac{4}{5}$ of a ton on the protected series and but $\frac{1}{5}$ of a ton on the check.

Figs. 9 and 10 serve further to indicate what may be done with this type of soil even after it has become badly washed and gullied.

Altho these results show in principle the possibility of improving this land, it cannot be said that the experiments as conducted represent directly the most economical system of farming. However, it appears possible that by modifying the cropping plan in some manner, as for example, substituting sweet clover for cowpeas and giving large place in the farming system to hay and pasture crops, production might be substantially increased and thus a system of farming instituted that would represent a profitable enterprise.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
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7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
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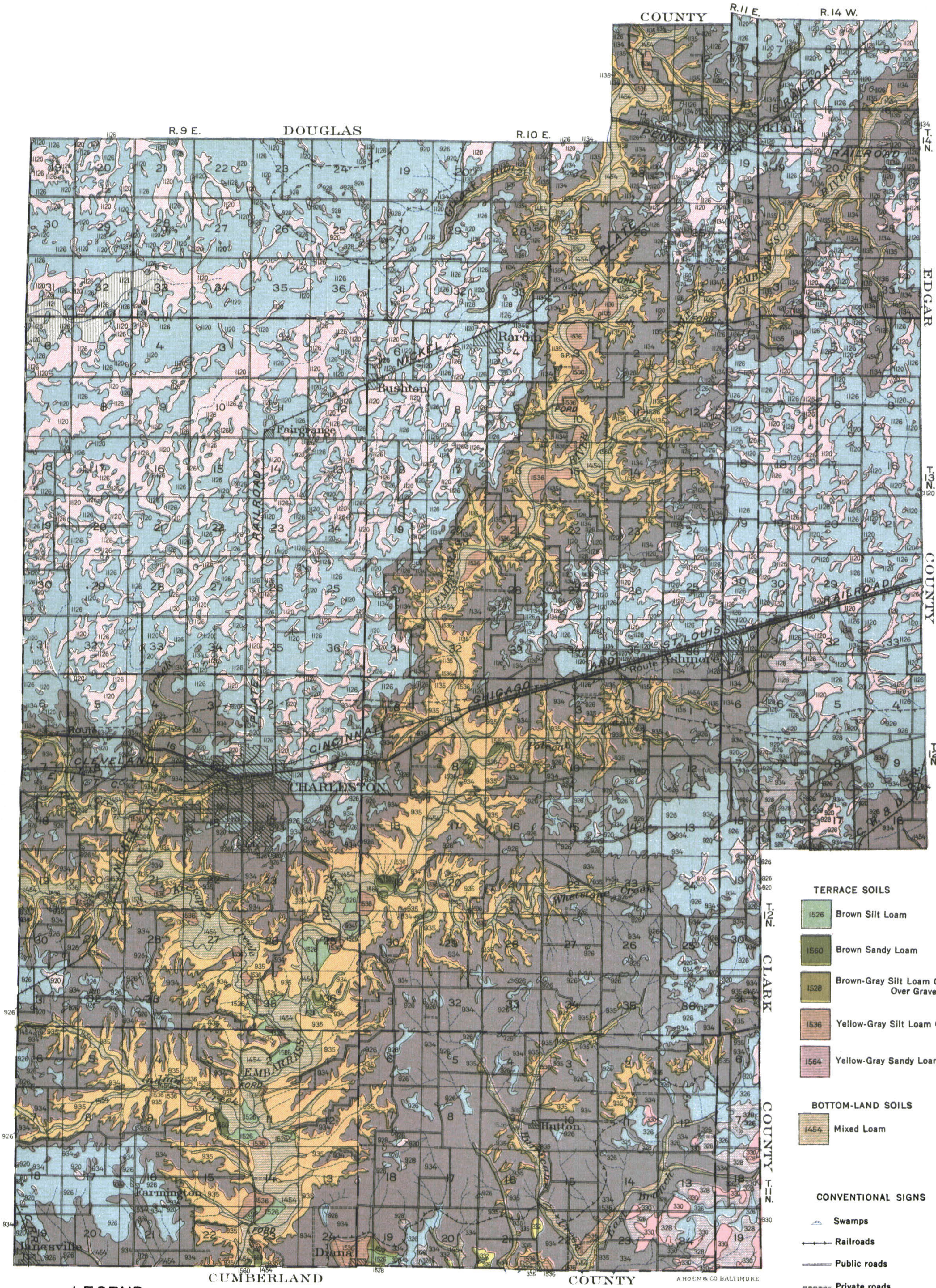

LEGEND

300 Lower Illinoisan Glaciation
900 Early Wisconsin Moraines
1100 Early Wisconsin Glaciation
1400 Swamp and Bottom Land
1500 Terrace

UPLAND PRAIRIE SOILS

- 326, 926, 1126 — Brown Silt Loam
- 320, 920, 1120 — Black Clay Loam
- 1121 — Drab Clay Loam
- 328, 928, 1128 — Brown-Gray Silt Loam On Tight Clay
- 330 — Gray Silt Loam On Tight Clay

UPLAND TIMBER SOILS

- 334, 934, 1134 — Yellow-Gray Silt Loam
- 335, 935, 1135 — Yellow Silt Loam
- 332, 1132 — Light Gray Silt Loam On Tight Clay
- 364 — Yellow-Gray Sandy Loam

TERRACE SOILS

- 1526 — Brown Silt Loam
- 1560 — Brown Sandy Loam
- 1528 — Brown-Gray Silt Loam On Tight Clay Over Gravel
- 1536 — Yellow-Gray Silt Loam Over Gravel
- 1564 — Yellow-Gray Sandy Loam

BOTTOM-LAND SOILS

- 1454 — Mixed Loam

CONVENTIONAL SIGNS

- Swamps
- Railroads
- Public roads
- Private roads
- Interurbans
- Canals
- Morainal boundaries
- Township lines
- Paved roads

Scale
0 ¼ ½ 1 2 Miles

SOIL SURVEY MAP OF COLES COUNTY
UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

LEGEND

300 Lower Illinoisan Glaciation
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- Swamps
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- Morainal boundaries
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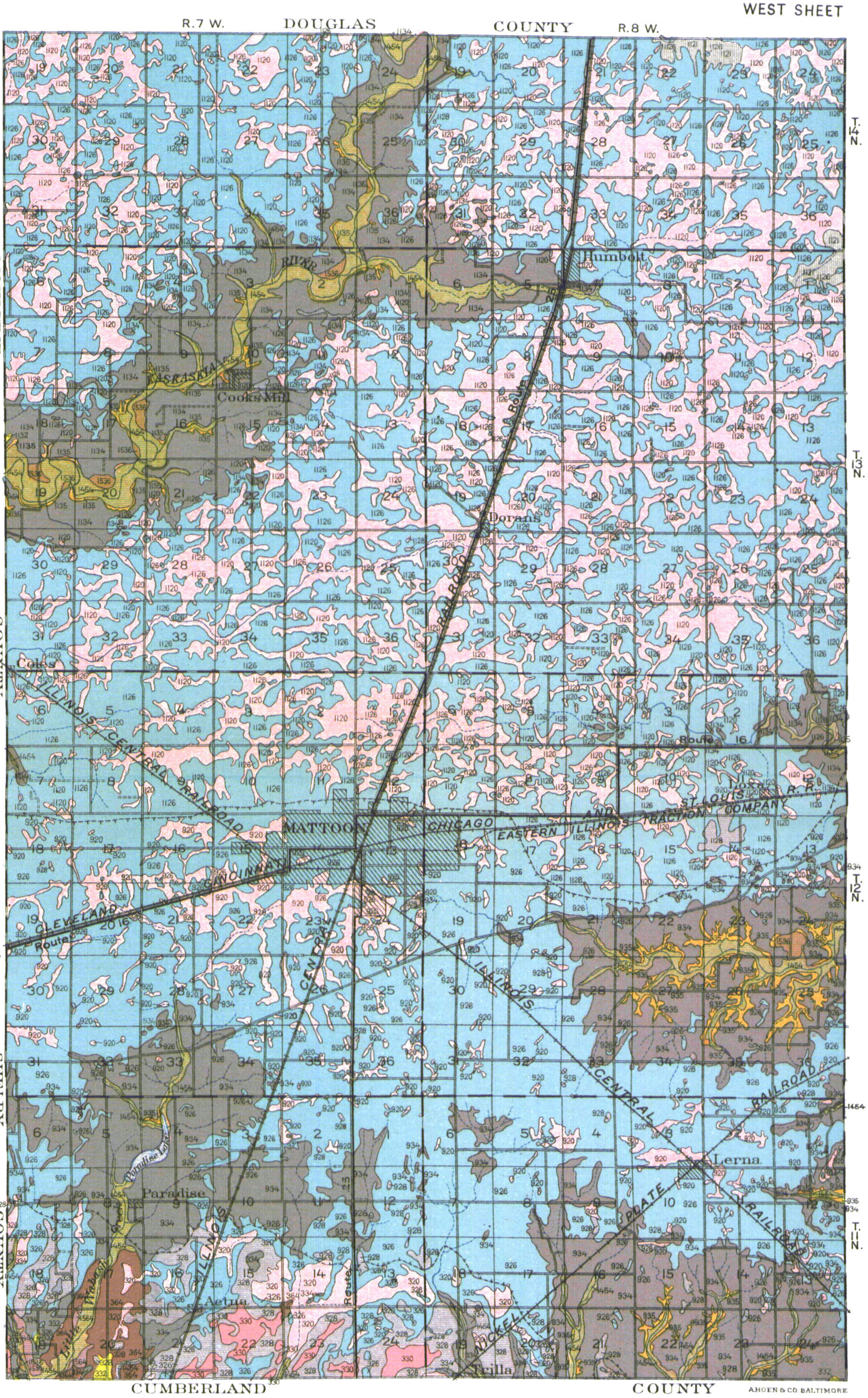
Scale
0 1/4 1/2 1 2 Miles



SOIL SURVEY MAP OF COLES COUNTY
UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION